The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

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# EDITORIAL.

It is now just ten years since the first issue of the ILLUMINATING ENGINEER appeared, and we are celebrating the occasion by making this a SPECIAL TEN YEARS' ANNIVERSARY NUMBER.

On pp. 6—19 we reproduce the paper read by the writer before the last meeting of the Illuminating Engineering Society entitled "Ten Years of Illuminating Engineering: its Lessons and Future Prospects." We are also including (pp. 23 onwards) a series of typical letters received from those prominently associated with various aspects of illumination, referring to the work of the journal and its relation to the problems with which they are mainly engaged.

We treasure these messages, not only as a timely recognition of the importance of the movement to all sections of the lighting industry and to the public, but as a confirmation, after ten years' experience, of the hopes with which the movement was begun. They constitute a permanent record of progress, revealing how many are the fields for useful service in illuminating engineering, and will no doubt prove an inspiration to others to associate themselves with this work.

## The Commencement of the Illuminating Engineering Movement in this Country.

In the paper read at the last meeting of the Society it was remarked that the movement originated at the meeting of the Association of Engineers-in-Charge on December 11th, 1907; but before this date efforts were already being made to bring together those interested in lighting in this country. The writer had previously undertaken visits to the United States and the chief European countries in order to be informed of the progress in illumination in those countries, and to enlist the co-operation of the chief experts in lighting in different parts of the world. These and other steps were described in the first issue of the ILLUMINATING ENGINEER, which appeared on January 1st, 1908. During this year the journal served to explain the aims and objects of the proposed Illuminating Engineering Society.

In the following year the Society was launched. Preliminary steps were agreed upon at an informal dinner held at the Criterion Restaurant on February 9th, 1909, and the Society was actually formed at a meeting at St. Bride's Institute on May 25th. At the Inaugural Meeting, held at the Royal Society of Arts on November 18th, the First President, the late Professor Silvanus P. Thompson, delivered an inspiring Address which has never been surpassed as an exposition of the aims of the Society. The Cantor Lectures delivered by the writer before the Royal Society of Arts in 1909 on "Modern Illuminants," at which all the chief illuminants were exhibited, also helped to kindle interest in the movement. To the Royal Society of Arts, under whose fostering care so many new societies have come into being and assumed independent existence, the Illuminating Engineering Society owes a special debt of gratitude for their constant encouragement and the hospitality which it has exercised since the Society's inception.

Since then the movement has made steady progress, though initially it involved much uphill work. It was necessary to kindle an interest in illumination to show its vast possibilities and, in some cases, to remove old prejudices, by the harmonious co-operation of the members of the Council of the Society, and the services of the large number of corresponding members in different countries to whom special problems were referred for elucidation as they arose. The writer would like to make special acknowledgment of the able assistance rendered by his friend and co-worker, Mr. J. S. Dow, who has been associated with him in this work since the commencement of the movement. We have all felt that we were engaged on a labour of love and a process of self-education. Our eyes were enchanted by the glamour of a new field of knowledge, with so many rich unexplored regions and such countless interesting channels of communication with other studies. Originally the neglected step-child and "nobody's business," illumination is now coming to be rightly recognised as the concern of everybody—an essential alike in daily life and in every vocation.

It is a legitimate source of pride that this was the first country in Europe to recognise the importance of illumination by founding a special society for its study, and our journal, which has been the official organ of the Society since its foundation, is still the only one in Europe devoted exclusively to lighting problems and the impartial treatment of all illuminants.

## How Knowledge on Illumination is Spread.

The journal and the Society have been continually interesting new sections of the public in the subject.

Since its formation in 1909 the Society has held 52 meetings. The total attendance obtained by adding up the number of people present at each meeting approaches 4,000, approximately half of whom have been visitors interested in various aspects of illumination, and contributions by about 300 different people (either spoken or communicated) have been made at these meetings.

As an indication of the scope of these discussions it may be of interest to quote a few of the subjects dealt with :—

The eye as affected by varying degrees of brightness and contrast ; glare, its causes and effects.

Photometry and the measurement of light and illumination ; photometric units and magnitudes ; the marking and rating of lamps ; the lumen.

Progress in gas, electric, oil, acetylene, and petrol air gas lighting.

The lighting of streets, schools, libraries, railway stations and yards, printing works, picture galleries and museums, cinema theatres, etc.

Glassware, shades and reflectors, and fixture design.

Miscellaneous : Colour discrimination by artificial light ; daylight illlumination ; shadows by natural and artificial light ; indirect lighting ; motor-car headlights.

War-time problems : searchlights, the lighting of rifle ranges, illuminating engineering in war time, fluorescence and phosphorescence (and their relation to special uses of luminous paint) ; economy in lighting in relation to fuel saving ; factory lighting (discussion on Home Office Report).

This list is enough to show the wide-ranging scope of the Society's discussions, but does not include the many separate articles on lighting problems of the most varied kind that have appeared in the ILLUMINATING ENGINEER.

The Society has also extended the movement by its participation in a number of International Congresses, amongst which may be mentioned :—

The International Congress on Industrial Hygiene (Brussels, 1910) ; the International Hygienic Congress (Dresden, 1911) ; the International Electrical Congress (Turin, 1911) ; the First International Congress for the Prevention of Industrial Accidents (Milan, 1912) ; the Fourth International Congress on School Hygiene (Buffalo, 1913) ; the Annual Congress of the Royal Institute of Public Health (Paris, 1913).

It has likewise been represented on a number of Joint Committees on specific problems in lighting, among which may be mentioned :—

The National Illumination Commission ; the Joint Committee on the Standard Specification of Street Lighting ; the Joint Committee on School Lighting ; the Joint Committee on Library Lighting ; the London Safety-First Council ; the Committee on Illuminating Engineering, acting under the Department of Scientific and Industrial Research.

Since the outbreak of war it has also formed two special committees to carry on researches for Government Departments on luminous tubes containing radioactive paints, and on starshells and flares.

The work of this journal, as the vehicle by which the knowledge acquired by the Society is brought to the notice of the general public, has been greatly aided by the daily, scientific, and technical journals in this country. The ILLUMINATING ENGINEER is habitually quoted in more than 100 journals, and the illuminating engineering movement is thus brought to the notice of the public in a remarkably wide and searching manner. Once the aims of the Society were generally understood it received from that time onwards the most generous recognition from the Press, which we gladly take this opportunity to gratefully acknowledge.

## The Future of Illuminating Engineering.

While at the moment progress in some fields of lighting—street lighting especially—is at a standstill, we feel confident that ultimately progress will be resumed at a more rapid rate than ever before. Some possibilities are discussed in the concluding portion of the paper on "Ten Years of Illuminating Engineering," appearing in this issue; others are indicated in the series of letters on pp. 23—41. Beneath the troubled surface in the lighting world research is still proceeding. After we have returned to normal conditions many of these will doubtless see the light and an era of unprecedented development may ensue. In regard to illuminants, we know full well that even the most efficient sources only produce as light a small fraction of the energy they receive. Some day we may be able to control completely the energy from such sources, producing only just the intensity and colour of light we require.

Simultaneously we may anticipate progress on a similar scale in the distribution of light; large public buildings and others may be designed for artificial light, in the same way as they are now, to a great extent, constructed with a view to proper admission of daylight. The artificial illumination would then become an essential part of the whole scheme of decoration—mouldings, panels, recesses and ceiling being constructed to serve as receptacles for light sources so that every part of the room received its allotted illumination, and the illuminant is revealed only through the effect produced. The artistic aspects of interior lighting, and the possibilities of light and colour as adjuncts to stage productions will doubtless be further developed.

In exterior lighting even greater changes may come to pass. Instead of lamps of obtrusive brilliancy, located at irregular intervals and without any attempt to secure a harmonious effect, the illumination of streets and squares will be studied as a whole. Lamps will be so shaded and diffused as to serve no longer as a menace to traffic; glaring masses of lights for purposes of advertisement will be replaced by artistic concealed lighting effects, and similar devices will be used to show up the exteriors of prominent buildings by night, until at length the conditions in the streets of a city come to resemble much more closely those prevailing in well-lighted interiors to-day, though naturally the illumination will be pitched in a lower key.

Finally, an entirely new section of exterior lighting may arise to meet the requirements of traffic in the air. Not only will the aircraft—applied ultimately to the peaceful purposes of goods, postal and passenger traffic—carry headlights, but they will themselves require to be guided by illuminated signalling devices on the ground. Landing-places will require special illumination and, in contrast to the conditions that prevail in war, our aim will be so to illuminate our cities that aircraft overhead will be able to recognise every landmark. On festive occasions aircraft circling overhead may themselves serve as luminous creatures of the air, sparkling with irridescent colours, or producing illumination equivalent to artificial moonlight on the ground below.

These may appear visionary expectations, yet, with our knowledge of the progress of the last ten years, it is difficult to set a limit to what the future may bring forth. Illuminating engineering has wrought great changes, but its greatest benefits to mankind are still to come.

LEON GASTER.

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**Founder and Editor of "The Illuminating Engineer"**

Hon. Secretary of

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MR. LEON GASTER, the youngest son of Chevalier A. E. Gaster, was born at Bucharest, Roumania, partly educated at Bucharest University, and continued his studies at the Zurich Polytechnic from 1891–1895.

In 1908 he founded *The Illuminating Engineer*, of which he has had editorial charge since its inception. The ILLUMINATING ENGINEERING SOCIETY, of which he has been Hon. Secretary since its commencement, was founded on his initiative in London in 1909.

Mr. GASTER is an *ex-officio* member of all the standing committees of the Society. He is a member of the Home Office Departmental Committee on Lighting in Factories and Workshops; Lighting Adviser to the Home Office Industrial Museum; Member of the Committee on Illuminating Engineering under the Department of Scientific and Industrial Research; Member of the National Illumination Commission; Member of the London "Safety First" Council and Chairman of the Sub-Committee on Street Lighting; Fellow of the Institute of Journalists and Chairman of its Circle of Scientific, Technical and Trade Journalists.

Mr. GASTER received the Silver Medal of the Royal Society of Arts in 1906, and was the first Cantor Lecturer to cover all the chief illuminants in a series of four lectures delivered early in 1909. He has lectured before many learned Societies and International Congresses on the subject of Illumination.

Mr. GASTER came to this country in 1895, becoming naturalised in 1902. He has practised as a Consulting Engineer since 1900, and is adviser on lighting and power transmission to a large number of factories engaged on Government work.

**TRANSACTIONS**

OF

**The Illuminating Engineering Society.**

**(Founded in London, 1909.)**

*The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.*

# TEN YEARS OF ILLUMINATING ENGINEERING: ITS LESSONS AND FUTURE PROSPECTS.

(Proceedings at a Meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W., at 5 p.m. on Tuesday, January 15th, 1918.)

A MEETING of the Society took place on Tuesday, January 15th, 1918, at 5 p.m., the Chair being taken by the PRESIDENT. The minutes of the last meeting having been taken as read, the names of the following new applicants for membership were read out by the Hon. Secretary :—

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| Mr. W. H. Bennett | Managing Director, The Gas Works, Redhill. |
| Mr. A. R. Edwards | Late Major 3rd Battalion A.I.F., Public Works Dept. Sydney, N.S.W. |
| Mr. J. H. Meade | Engineer-in-Charge (Heat, Light and Power), Aircraft Factory, Farnborough. |

The names of applicants announced at the previous meeting were also read out again, and these gentlemen were formally declared members of the Society.*

Mr. L. GASTER was then called upon to deliver his address, entitled "Ten Years of Illuminating Engineering: its Lessons and Future Prospects" (see pp. 6-19), in opening which he recalled that it was just ten years since the proposition to form an Illuminating Engineering Society in this country was made. The moment was, therefore, opportune to survey the progress.

After reviewing in some detail the work of the Society, Mr. Gaster emphasised the need for fuller confirmatory data, illustrating the relation between illumination and health, accidents, and quality and output of work. Some tables were presented, showing how data could be assembled on a uniform basis, enabling the connection to be traced between lighting conditions and accidents in streets and factories.

In the discussion that ensued, Mr. E. WILLIS, Mr. NEWTON KNIGHTS, J.P., Mr. HOWGRAVE GRAHAM, and THE PRESIDENT took part. Mr. WILLIS and Mr. NEWTON KNIGHTS, who are associated with the London Safety First Council, discussed the problem of obtaining fuller data on accidents, expressing their appreciation of the importance of adequate illumination in streets for the safe guidance of traffic. THE PRESIDENT, in winding up the discussion, moved a vote of thanks to Mr. GASTER for his address, and announced that the **next meeting** would take place on **February 26th,** when a paper, entitled "**A Survey of Methods of Directing and Concentrating Light,**" would be read by **Lt.-Commander Haydn T. Harrison, R.N.V.R.**

* *Illum. Eng.*, Dec., 1917, p. 305.

# TEN YEARS OF ILLUMINATING ENGINEERING: ITS LESSONS AND FUTURE PROSPECTS.

By L. Gaster (*Hon. Secretary*).

(Address delivered at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 5 p.m., on Tuesday, January 15th, 1918.)

Synopsis.

(*a*) *A Brief Survey of the Past Ten Years.*
(*b*) *Relations with other Bodies, and some Suggested Methods of Further Co-operation.*
(*c*) *Relations with the State.*
(*d*) *Illuminating Engineering as a Profession and the Training of the Illuminating Engineer.*
(*e*) *The Accumulation of Evidence of the Utility of Illuminating Engineering.*

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A little more than ten years have elapsed since the project of forming an Illuminating Engineering Society was brought forward by the author at a meeting held at the Association of Engineers-in-Charge on December 11th, 1907. The *Illuminating Engineer* was started shortly afterwards, in January, 1908. Previous to this the writer had visited the United States, where an Illuminating Engineering Society had been recently formed, and the chief Continental countries, where he had consultations with the leading experts on lighting. These inquiries suggested that an Illuminating Engineering Society, if conducted in a broad and impartial manner, would receive support in this country. After ten years' experience we can justly say that this hope has been fulfilled, and we have the satisfaction of feeling that in this branch of work, at least, this country has taken the lead in Europe.

It is interesting to recall that at this first meeting in December, 1907, Mr. Trotter, our President, took the chair. Now ten years afterwards, he is presiding over our Society.

## A Brief Survey of the Past Ten Years.

After the comprehensive survey of the work of the Society given in the Presidential Address last month, it seems unnecessary to say much under this head, and in the time available I can only touch on a few out of many interesting developments. I should like to refer those interested to several papers and articles summarising the Society's aims and objects.*

But after the lapse of ten years it is useful to take stock—to see how far our aims have been realised and what further steps are practicable. In what follows we shall deal—(*a*) with the essentially scientific work of the Society, *i.e.*, those problems which require original work and of which we have as yet only partial solutions, and (*b*) with the further question how the knowledge acquired can best be applied, and how we can induce others to make use of it.

During the last decade there have been great advances in the lighting art. Partly owing to improvements in the efficiency of illuminants, partly through our efforts to encourage better lighting,

* See Inaugural Address by Professor Silvanus Thompson, *Illuminating Engineer*, Vol. II., 1909, p. 813.

"The Aims and Objects of the Illuminating Engineering Society" (paper read at the National Gas Congress, October 17th, 1913.—*Illuminating Engineer*, Vol. VI., p. 561.

"The Work of the Illuminating Engineering Society." – *Illuminating Engineer*, August 1914

"The Illuminating Engineering Movement in Great Britain."—*Beama Journal*, April, 1915.

the standard of illumination rose steadily until the check imposed by the war. People not only use more light—they are much more concerned about how it should be used.

I invite confirmatory evidence from other members on this point. To me it appears that already less stress is laid on mere brilliancy of the source, but contrast with surroundings, shadow-conditions, direction of light and avoidance of glare receive much more consideration. A source cannot be considered complete without its appropriate shade, globe or reflector. While ten years ago there were few familiar with polar curves, they are now coming to be considered an essential element in judging lamps and lighting appliances. But we have still to reach the point that such curves will only be accepted as satisfactory when they have received the hall-mark of an independent and responsible authority.

An important feature in this progress has been the development of illumination-photometry. In the year 1908 values in foot-candles were rarely mentioned. Now the term is much better understood, and there is quite a variety of choice in illumination photometers, many hundreds of which are in use, some for special and novel applications in connection with the war.

In what directions is progress in illumination-photometry desirable? Apparently in two: (*a*) the design of simpler and more compact types for general work involving approximate determinations of illumination in practice, and (*b*) in the production in this country of more accurate forms suitable for use in scientific investigations and in settling disputes relating to contracts. Already, however, the readings of existing instruments have been used in cases of dispute.

### Relations with Other Bodies.

Among the various difficulties raised when the project of starting the Society was brought forward, two may be mentioned: (1) it was feared that harmonious co-operation between representatives of rival systems of lighting would not be possible; (2) it was complained that such "undue specialisation" was not desirable, that there were already too many technical societies.

With ten years' experience behind us, it is only necessary to mention the first point to dispose of it. Our discussions have been invariably amicable, and we have learned to appreciate, even more thoroughly than at the start, the extent of the common ground in which we are all interested. In the future the degree of co-operation may be greater; it will certainly not be less. There are some who anticipate much closer relations between gas and electrical supply companies after the war, and the fuller the mutual assistance rendered, the easier our task will be.

In regard to the second point, specialisation is surely but a natural result of scientific progress. As the President mentioned in his address, we have not trespassed on the province of the other societies, but have undertaken work that was previously regarded as "nobody's business" (although it concerned everybody). Much of this work could only have been done by a body representative of all illuminants, and providing an impartial platform, as our Society does.

Indeed, our Society may justly claim to act as a corrective to undue specialization. It is a "liaison-officer," linking up various experts and reducing their efforts to a common denominator. Whenever occasion served it has sought the co-operation of other bodies on topics of common interest and during the last ten years has possibly held more joint discussions than any other similar technical body. The discussions on school, library, and street lighting are cases in point.

It has also one "link" which hardly exists in the purely engineering and professional bodies—its ready means of contact with the general public. Illumination, while a fit subject for the specialist, enters into the daily life and occupations of almost everyone. We seek therefore to bring together both the producer and the user of light, lamps and lighting appliances. While essentially a scientific society, we welcome information from any quarter, and we have hitherto imposed no professional qualification.

The experience gained in our discussions

should have the effect ultimately of producing men with a good all-round knowledge of illumination, studied from every point of view.

**Illuminating Engineering as a Profession.**

When the Society was formed it was anticipated that one ultimate result would be the development of a new specialist — the illuminating engineer After ten years of experience, is there evidence of the development of illuminating engineering as a profession? I think we shall agree that this experience has strengthened the impression that the services of such experts are needed. But the course of events cannot be forced. We have had to await two things: (*a*) the acquirement of the necessary knowledge of lighting problems, and (*b*) the creation of a general appreciation of the value of good lighting, so strong as to encourage men to confine themselves to such work, or to make it the subject of special study. Is our knowledge now sufficient to justify us in offering expert advice with the necessary authority—on a subject, be it remembered, in which personal tastes and whims have often to be combated? I think we are approaching this point. The main principles of good lighting and the technical side of providing methods of complying with these principles are becoming clearer. As regards the second point (*b*), we were also approaching a favourable stage at the outbreak of war. Since then there has naturally been a check. Men were no longer free to undertake such work as they preferred, but only that most urgent in the national interests. Even during the war, however, circumstances have tended to bring home to people in general the importance of lighting, especially in our shops, streets, and factories, and afterwards we may anticipate that illumination will be more seriously considered than in the past.

Meantime, while there are few men who can fitly be termed "experts in illuminating engineering," there are many who are daily increasing their knowledge and applying it to practice. The formation of illuminating engineering departments by leading manufacturers of lamps and lighting appliances is an encouraging sign. In such cases illumination fills a legitimate sphere in showing how special varieties of lamps and fittings can be most effectively used, and it is very desirable that the public should receive guidance on this point. But it is naturally a more restricted field of work than that of the ideal impartial illuminating engineer, conversant with all methods of lighting. I should, however, like to remark that the work of the leading makers of lamps and lighting appliances, in thus associating themselves with illuminating engineering, has been extremely useful. They have very materially improved their products during recent years, and their practice of encouraging the public to ask for information as to their use has had a beneficial educational effect.

Before we, as a Society, describe ourselves as illuminating engineers, it would be necessary to impose some form of test of qualifications. Are we yet in a position to do this? We have not yet ventured to define precisely the necessary knowledge and training of the illuminating engineer, although we should agree on many subjects as essential therein. We must look mainly to our colleges to evolve this curriculum. Education has now better prospects than for many a long day, and it may be hoped that after the war courses in illuminating engineering may become more general. A start was made in the years preceding the war by the initiation of courses at a number of educational institutions in London. Meantime the very complete series of lectures delivered under the auspices of the American Society at the Pennsylvania University last autumn, deserve mention, and afford a suitable basis from which the course of training for the ideal illuminating engineer might be built up. It will no doubt be desirable for this matter to be studied in due course by a Committee of the Society which could approach educational authorities regarding suitable courses of instruction in illuminating engineering.

Finally, we may inquire what would be the relations of the illuminating engineer to other professions. Probably his services would be in request chiefly in the case of large installations, especially those involving new problems

and original design. His work would be supplementary to that of the architect and the contractor, and would not compete with it. Just as a general practitioner has no hesitation in calling in the services of a specialist on certain diseases or in certain forms of medical treatment, so the architect might accept the help of the illuminating engineer in special lighting problems, or where long experience of intricate calculations is involved. From his experience he becomes familiar with the latest developments in lamps and fittings best adapted to the processes carried on in the factory under consideration, and with the degree of illumination desirable in each case in order to secure the best output and the most efficient conditions of working. His co-operation in deciding these points would therefore often be very valuable.

Points in professional procedure will no doubt be settled in due course as the illuminating engineer develops. The informal relations now being established with other bodies should be helpful in this respect. By discussion of problems of common interest the nature of the services to be rendered by illuminating engineers will be made more definite, and I now propose to say something further on methods of co-operation that might with advantage be encouraged with other professions and societies in the near future.

## Further Methods of Co-operation with other Professions, Societies, with Industry, and with Gas and Electrical Supply Companies.

Assuming the need for co-operation with other bodies, we may ask what other steps might be taken to cement these relations, to make our aims better known, and to make our work more effective ? Joint meetings, supplemented by joint committees to consider points in detail, are very helpful. No doubt this form of co-operation will be extended in the future. In this way we secure the aid of those members of other bodies who are already interested in illumination, and sufficiently conversant with its principles to help us in the solution of new problems. But in order to come in contact with the rank and file of other bodies, it would be useful if some of our members could read papers, bringing before them at their own meetings the points on which we need information or can afford guidance. We have had favourable experience of this method of propaganda in connection with various international congresses in the past. By our participation therein we extended our sphere of influence and gained a number of useful new members.

Among the bodies whose aid we might seek in this way may be mentioned the medical profession, whose prestige is widely recognised by the public, and whose influence in support of good illumination it would be very useful to secure. At our meetings we have had the valued help of a number of physiologists and medical men. But we should now try to reach a further stage, and kindle in doctors generally our own enthusiasm for proper methods of lighting. Medical officers of health, school doctors and medical men associated with factories are in a position to educate the public on a large scale.

Next we have the architects, on whose connection with illuminating engineering something has already been said. The relation of the architect to lighting matters is somewhat indefinite. In the case of factories, for example, his work is frequently confined to planning the building, and the lighting arrangements are left to the contractor. But in the case of churches, hotels, and public buildings, &c., the lighting arrangements are often left in his hands, though generally regarded as subsidiary to his main work. The problem of interesting the architect in illuminating engineering has still to be solved, and it may be found necessary to open the channel of communication by a series of lectures and papers, showing that we have information of value to impart. There are many points of common interest: the predetermination of the admission of daylight by photometric methods; the combination of design of the structure of buildings, with the planning of the lighting; and the wise field of the decorative aspects of illumination, both in interior and exterior lighting. On these points we already know a certain amount. Our task must be to reduce our knowledge to practical shape,

and to demonstrate its value in architectural problems.

Other problems will suggest themselves. Could we not associate ourselves with the Textile Institute, the Society of Dyers and Colourists, and similar bodies, in studying the effect of the colour of light from illuminants on fabrics, the possibilities of "artificial daylight," &c.?

While there are many societies whose co-operation we gratefully acknowledge, the opportunity should not be allowed to pass of referring to the special encouragement which we have received, from the very commencement of our work, namely, the Royal Society of Arts, whose hospitality we enjoy. The Royal Society of Arts was among the very first to recognise the value of illuminating engineering, and its distinctive field of action.

I now come to two classes of men whom it should be our special object to influence—contractors and members of the staff of gas and electrical supply companies. Why is it that we have hitherto not received the general support that we might naturally expect in these quarters? I think it is because our work has dealt mainly with discussions and settling general principles, and necessarily so. But now that the main principles of illuminating engineering have become clearer, we might present problems before them in a more practical way. Simultaneously, as the movement advances, we hope that the growing demand for more scientific lighting will eventually induce them to study our work more closely.

With a few honourable exceptions, gas and electric supply companies have not devoted themselves to illuminating engineering in the way one might expect.

The old conception that the business of a supply company ends at the consumer's premises has not passed away completely, though progress was being made until the outbreak of war. War conditions, with the technical difficulties experienced in the supply of electricity and gas, and the shortage of staff, and also the lighting restrictions, have been unfavourable to the development of the illuminating engineering branch of a supply company's work. On the other hand, the special measures taken in some instances to explain to consumers the need for economy may help to pave the way for the future education of consumers in lighting matters.

In the future, I believe, both supply companies and contractors for gas and electric lighting will find it advantageous to study the needs of the consumers much more closely. Contractors and members of the staffs of supply companies might be encouraged to attend meetings of the Society, but it may be that many of our discussions are of too technical a character to be appreciated by those little conversant with illuminating engineering. The gap might be filled by courses of lectures of a more elementary but practical kind, organised at educational centres under the supervision of the Society and a group of local supply companies and contractors. We must also not lose sight of the fact that members of companies in the provinces are unable to attend our London meetings, and can only become conversant with our work through the journal. Shortly before the war we were taking steps to form the nuclei of branches of the Society at the chief industrial centres. It is hardly practicable to do much in this direction at present, but the matter should be taken up as opportunity affords.

In passing, it may be remarked that women might well be trained to do part of the work in approaching consumers on behalf of supply companies, and in some cases already undertake certain sections. After all, the heating, cooking, and lighting arrangements in the ordinary house rest largely in women's hands, while in some vocations, as school teachers, factory inspectors, medical officers of health, &c., they are brought in practical touch with lighting problems. It appears, therefore, there is an opening for the service of women in illuminating engineering, and it will be recalled that membership of our Society is open to both sexes.

Another way in which our Society could assist supply companies, as well as manufacturers of lamps and lighting appliances, is by preparing suitable lectures and leaflets, stating in simple terms the chief essentials of proper lighting. In the United States the Illuminating Engineering Society appears to have done good work in this direction recently

by their "codes" on the lighting of factories, schools, &c., and by the preparation of standard lectures on such subjects as school, domestic, and shop lighting. I notice that one manufacturing firm makes a practice of issuing such lectures to contractors, architects and others, together with slides and even a small portable lantern.

Another useful field for co-operation between our Society and supply companies, contractors, and makers of lighting appliances is in connection with demonstrations of method of meeting various lighting problems. I recall that at an exhibition held in Berlin in 1908, a series of model shop-windows was arranged, a prize being offered for the best-lighted exhibit. At this exhibition a number of windows of identical size and shape were constructed, and those taking part in the competition were required to light the window at a first cost of 500 marks (approx. £25). The nature of the illuminant and the style of lighting were left to the exhibitor, but a fixed rate for electricity and gas was given in order that running costs might be stated on a uniform basis. Recently in the United States an entire block of stores was lighted on a model plan by the local supply company, as an exhibit. Such exhibits form a useful method of approaching the public, provided they really represent the most approved method of lighting. In the earlier days we might not have ventured to become responsible for such a display, but with the experience gained we might now do so, and the exhibit would be more highly regarded if it received our support. There is no reason why model lighting installations of many kinds, shops, schoolrooms, workrooms, and even streets should not be arranged in the future, prizes being offered for the best results secured.

Having thus considered the best forms of co-operation between scientific and technical bodies, let us next turn to another very important question—the relations of such bodies with Government Departments and with the State.

## Relations with Authorities and with the State.

At a time like the present we are all naturally anxious to help the authorities in every way we can, and to put any special knowledge we have at their disposal. The President has mentioned several instances in which we have been of assistance by undertaking special experimental work. In common with other societies, however, we have felt that we might have done much more had the proper machinery for enlisting the support of scientific and technical bodies been available at the outbreak of war. In such work as the darkening of streets, the lighting of munition works, and the promotion of economy in illumination, our special knowledge should naturally be helpful, and many other war-problems into which the application of light enters could no doubt be mentioned.

A recent Order appearing in the *London Gazette* for December 25th, 1917, directed that "The Minister of Munitions, with a view to maintaining or increasing the supply of light, heat, or power for the purpose of the production, repair, or transport of war materials, or for any other work necessary for the successful prosecution of the war, may by order direct that lights of any specified class or description shall be extinguished or their use restricted to such extent, between such hours, within such area, and during such period or on such premises as may be specified in the order. . . ."

It is evident that the regulating of lighting in this way is a matter that requires considerable technical knowledge in order that its effect on consumers, supply companies, and factories may be properly considered, and on this matter our Society is in a specially favourable position to give advice and assistance.

The question arises what should be the proper attitude of a Society in regard to the State? In the absence of properly organised channels of communication through which prompt action could be taken, their only course is to offer their services wherever they see an opening, but it is largely a matter of chance whether their efforts are rewarded by useful work. Our Society followed this course at an early stage, and before the formation of the Conjoint Board of Scientific Societies. In many instances our suggestions have been acted upon, even in cases where the relation would not be evident to outsiders. Whilst in every case our offers

have been sympathetically received, in some instances no action has as yet been taken. It is quite evident that opportunities are missed in this way. Unless Societies are kept regularly and promptly informed of problems on which their aid would be useful their efforts may be sterilised. Fortunately out of the existing chaos closer relations may gradually be built up. The formation of the Conjoint Board of Scientific Societies under the auspices of the Royal Society has been a step in the right direction, and provided it is made fully representative, and its machinery is such as to ensure prompt appeal to the body concerned as soon as any problem arises, it should do useful service.

In the Committee on Illuminating Engineering, acting under the Department of Scientific and Industrial Research, which was formed last year, we have a valuable channel through which useful work will no doubt be undertaken in due course.

The United States Government, profiting by our experience, took measures on the outbreak of war to organise the assistance of the Illuminating Engineering Society in that country, which was invited to co-operate with the National Defence Council, in regard to the lighting of Government works, munition shops, arsenals, &c., and has since formed special committees to deal with such matters as visibility problems at sea and the lighting of aviation grounds.

The closer relations established with Authorities since the outbreak of war we hope will continue and develop further after peace is declared. In the work of the Departmental (Home Office) Committee on Lighting in Factories and Workshops, we have a good example of the importance of cultivating the sympathy of Government Departments, and enlisting their aid. It is gratifying to note that the Home Secretary, in reply to a recent question in the House regarding this Committee, strongly emphasised the value of good industrial lighting, and when opportunity offers the work of the Committee will no doubt be continued. Meanwhile, in America the Society has been successful in aiding several of the States, such as Pennsylvania, Wisconsin and New Jersey, to frame regulations on factory lighting, and these regulations appear to have worked on the whole well in practice.

The wide connections and representative character of our Society, particularly the fact of both users and producers being included in its membership, place it in a strong position, and I hope that in course of time all the chief Government Departments concerned with lighting will make use of our services in a more organised and regular manner.

A further matter for consideration is our relation to municipal authorities, for example, in such matters as street-lighting, and likewise the imposition of regulations for motor-car headlights, which has been the subject of much discussion in the United States. In these fields we are naturally restricted at present, but the experience being gained through our relations with the Safety First Council, and their attitude to lighting in relation to traffic, will be of value after the war. A kindred problem is the establishment of closer relations with educational bodies, and the work of our Committee on School Lighting must be taken up with renewed energy at the first opportunity. Having now definite recommendations to make on this subject, our next task must be to see that they are brought prominently before the notice of those in whose hands the provision of illumination in schools rests.

**Industrial Reconstruction.**

I should also like to refer to one problem that is being now presented to specific industries under the title of "Industrial Reconstruction." The well-known Whitley Report Recommendations, advocating the establishment of joint industrial councils, representing both employers and employees, to deal with the problems incidental to each particular trade, have been expanded by Mr. E. J. P. Benn and others in the form of a National Industrial Reconstruction scheme, according to which each trade would be controlled by a joint council of the kind described, but acting under a Government Department concerned with trade and industry. The Councils would deal not only with labour problems, but with such matters as industrial research, technical education,

the preparation of statistics relating to the trade, &c.

It is for us to consider how far it would be possible for the lighting industry to be represented in such a scheme.

One very important field of work to be undertaken in specific industries is the accumulation of statistical data relating to materials, manufacturing facilities, and markets. Such information is much needed in connection with some branches of illuminating engineering, such as lamps and glassware. There are, however, data covering a much wider field which it should be our duty to obtain, and a few typical instances of such information will next be presented.

## Suggested Collection of further Statistical Data, illustrating the utility of Illuminating Engineering.

The accumulation of statistical evidence to substantiate the claims made on behalf of illuminating engineering will be of great assistance in our future work. We are all agreed as to the benefits of good illumination, but in order to bring this home to the general public it would be extremely useful to have detailed evidence of the results to be gained by improved methods of lighting – facts which can be presented to show that good illumination is essential to health and to efficient and economical work.

I may take as a starting point a quotation from a book that has just been issued by the M.O.M. Committee on the Health of Munition Workers,* summarising the admirable series of bulletins which this Committee has prepared during the war. This record of useful work reflects great credit on the Chairman of the Committee, Sir Geo. Newman, and its energetic Secretary, Mr. E. H. Pelham. Among other matters, lighting is referred to, full endorsement being given to the conclusions of the Home Office Committee.

It is stated: "The results of inadequate illumination are damage to eyesight and personal health, various forms of domestic insanitation, accidents in factories and workshops, often accompanied by diminution in output of work and the lack of discipline. Bad lighting affects output unfavourably, not only by making good and rapid work more difficult, but by causing headaches and other effects of eye strain. Attention should be paid to the lighting of passages, offices, and the immediate surroundings of the factory, as well as that of the factory itself."

Now I take it that we are all agreed as to the truth of these statements.*

It is common knowledge, for example, that inadequate lighting is prejudicial to health, and liable to cause eye-strain. But it would be useful to be able to substantiate this view by statistics, proving beyond all question, by a detailed survey of the health and eyesight of factory-workers, the prejudicial effects of inadequate lighting. One of our tasks in the future must be to set in motion machinery for acquiring this data.

Again, while it is agreed that defective lighting necessarily handicaps the worker, and tends to restrict output and prejudice quality of work, it is difficult to obtain permission to publish first hand evidence of this, partly because there is not available adequate machinery for collecting such information, and partly because manufacturers are sometimes reluctant to furnish particulars, even where tests have been made. Some instances were mentioned in the evidence before the Home Office Committee, but we have insufficient statistical data relating to various trades. Much useful information could be obtained by comparing the quality and output of work, and the health of operators in various factories where identical processes are being carried on, and where the conditions of the illumination vary. The results of such an inquiry would be so valuable as to well repay the time and

* *Health of the Munition Worker*, a Handbook prepared by the Health of Munition Workers' Committee (published by His Majesty's Stationery Office, Imperial House, Kingsway, W.C.2, 1s. 6d. net).

* For further information on these points readers may be referred to the discussion of the Home Office Report on Lighting in Factories and Workshops (*Illum. Eng.*, Sept. and Dec., 1915; Feb., 1916). See also *The Economist and Hygienic Value of Good Illumination*, by L. Gaster (*Jour. Roy. Soc. Arts*, Feb. 7, 1913); "Industrial Illumination," by L. Gaster (*Cassier's Engineering Magazine*, Nov. 1917).

# DATA ON STREET ACCIDENTS.

Ref. Number _____

TABLE I.

DATE .....

## A. Particulars of Illumination, &c.:—

| Time of Day. | Nature and Probable cause of Accident. | Place where Accident occurred. | Condition of Roadway (*e.g.*, if slippery through rain or surface badly kept, etc.). | Conditions of Illumination. | | | | | | | | | | Nature of Screening. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Daylight | | | Artificial Light. | | | | | | | Proportion of Lantern Obscured. | | |
| | | | | Clear | Light Mist. | Dense Fog | Good. | Fair. | Very Dark. | H'ight of Lamp. | Distance of Nearest Lamp. (*Feet.*) | | | Darkened. | Clear. | Distempered |
| | | | | | | | | | | | Alight (*Feet*). | Alight. | | Extinguished.* | | |
| | | | | | | | | | | | | Gas. | Elect | By order. | By accident | |
| | | | | | | | | | | | | High pr's're | Arc lamp. | | | |
| | | | | | | | | | | | | Low pr's're | Glow lamp. | | | |

* If nearer to the spot where accident occurred than the lighted lamp. If more than one state number.....

## B. Particulars of Persons concerned, &c.:—

| Persons concerned in Accident.* | | | | | Injured Persons. | | | Fatal Verdict at Inquest (if any held). | Non-Fatal Nature of Injury to | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | Apparnt Age. | Sex. | Nationality. | Condition and Infirmity (*e.g.*, sobriety, short sight, deafness, etc.) | Faced Vehicle. | Had back to Vehicle. | Crossing the Road. | | Persons. | Property. | |
| | | | | | | | | | | | |

* Both Drivers and Pedestrians.

TABLE II.

# DATA ON ACCIDENTS IN FACTORIES AND WORKSHOPS.

## A. Particulars of Illumination, &c.

DATE OF ACCIDENT.....

| Hour or Day when accident occurred. | | Particulars of Factory where accident occurred. | Nature and presumed cause of accident. | DAYLIGHT (where accident occurred). | | ARTIFICIAL LIGHT (where accident occur'd.) |
|---|---|---|---|---|---|---|
| | | | | Atmospheric Conditions. | Access of Daylight into room. | |
| Night-shift | Day-shift | Name of Works :— | | Whether Clear..... | (*a*) State generally whether this was good, fair, or bad. | (*a*) State generally whether this was good, fair, or bad..... System of Lighting, whether gas (high or low pressure), or electric (glow lamps or arc lamps), direct or indirect..... Nearest lamp, approx. distance..... do. approx. ht. from floor..... |
| | | Address :— | | Dull ..... | (*b*) *Supplementary data to be entered on back of form.* | (*b*) *Supplementary data to be entered on back of form.* |
| | | Department :— | | Foggy ..... | (SEE TABLE III.) | (SEE TABLE III.) |

## B. Particulars of Persons concerned, &c.

| PERSONS CONCERNED IN ACCIDENT. | | | | | FATAL. | NON-FATAL. Nature of Injury to | | REMARKS. |
|---|---|---|---|---|---|---|---|---|
| Number | Age | Sex | Nationality | Condition and Infirmity (*e.g.*, sobriety, short sight, deafness, &c.) | Verdict at Inquest (if any held). | Persons | Property | |
| | | | | | | | | |

effort required, and if it could be undertaken first in a few trades, it would soon be extended to others. This is the kind of work which could much more easily be undertaken by a council representative of an industry as a whole, and for its common benefit, than by any individual manufacturer. This is only one instance of the way in which our work would be assisted by combinations representing specific trades.

One could thus ascertain the effect of the intensity of illumination and the arrangement of the lights. A record might be kept of the quality and output of work, and it would be useful to time specific processes in order to watch how the speed of work varied with the lighting conditions. In this way we should not only get direct evidence of the economic value of good illumination in factories but, by the practical elimination of unsuitable methods, would gradually arrive at the most favourable conditions for the various processes.

It may be pointed out that at the present time the Ministry of Munitions is in a specially favourable position to encourage a systematic inquiry on these lines. For it has under its charge factories carrying on identical operations, under standard conditions as regards hours of labour and wages, but lighted in different ways, and a relatively small amount of organisation would provide the machinery for obtaining the data we desire. The writer has been in communication with the Ministry on this subject.

**Illumination and Accidents.**

In order to show the relation between illumination and accidents in streets and factories, we should have to rely on statistical methods. The methods employed and stated in the Home Office Report furnished valuable evidence in regard to factories, but one would like to see them carried further. Similarly in the streets it would appear most useful if a complete survey of such accidents as occur could be made, both with normal illumination and the exceptional lighting conditions which prevail at the present time. Some official statistics on street accidents have been published in the *Illuminating Engineer* during the last three years, and, properly interpreted, they appear to yield presumptive evidence of the prejudicial effect of insufficient illumination. But the present methods of recording such accidents render it extremely difficult to trace the effect of illumination. In Table I there is presented a provisional scheme, showing how information on this point might be presented. It is very essential that all returns should be made on an uniform plan for purposes of comparison.

The information sought should not be difficult to obtain, but acquaintance with illuminating engineering would be needed in interpreting the results. I have not included the question of compensation, as I understand that information on this point would be difficult to obtain in individual cases; it would, however, be useful if the total compensation paid during a given period for accidents of a certain class could be obtained. The amount spent in such an inquiry would be relatively small in comparison with the useful conclusions that might be drawn regarding the conditions of illumination desirable. The problem is one on which insurance companies and those concerned with street traffic would no doubt be willing to co-operate with our Society.

In Tables II and III I have treated industrial accidents in a similar manner. While it is somewhat difficult to frame a table which gives all the information desirable and yet can be filled up without undue work, this might serve as an indication of what is proposed. Some of the data asked for in Table III clearly require technical knowledge, which could be obtained with our co-operation. The labour expended in such a survey would be well repaid. Few people realise that the number of street-accidents reported in this country every year exceeds the number of those who formed the original Expeditionary Force to France in the present war, while in factories roughly 160,000 accidents were reported in 1913, of which 1,287 were fatal.

It is surely worth our while to ascertain what percentage of these accidents can be traced to faulty illumination, and the nature of the defects to be avoided. The problem requires the co-operation of

TABLE III.

# ACCIDENTS IN FACTORIES AND WORKSHOPS.

## Supplementary Data on Illumination.

| DAYLIGHT (where accident occurred). | | ARTIFICIAL LIGHT (where accident occurred). | |
|---|---|---|---|
| 1. Nature of lighting—<br>Whether side or roof lighting or a combination of both ...<br>Whether N., S., E. or W., or a combination ... ... ... | | 1. Consumption of gas or electricity per square foot of floor area ... | |
| 2. Dimensions of room—<br>Height of room above ground...<br>Height of windows above floor level | | 2. Approximate illumination on work (Foot-candles)<br>Approximate (general) illumination at floor level in adjacent working area ... ... ... ...<br>(In foot-candles) | |
| 3. Window space per square foot of floor area { roof... / side... | | 3. Method of shading lamps and type of globes or reflectors used (if any) | |
| 4. Particulars of obstruction of light by neighbouring buildings, &c. (if any) ... ... ... ... | | 4. Was any glare caused—<br>(*a*) By bright light from sources striking directly into workers' eyes ...<br>(*b*) By reflection from polished sources ... | |
| 5. Nature of walls and ceilings (whether light or dark in colour) | | 5. Were any objectionable shadows cast by machinery or bodies of workers liable to cause accidents ... ... ... ... | |
| 6. Particulars of any artificial aids to daylight (prismatic glass, mirrors, &c.) ... ... ... ... | | | |
| 7. Ratio of illumination on work to unrestricted outdoor illumination | | | |
| 8. Was any glare caused—<br>(*a*) By direct sunlight striking into eyes of workers ... ... ... ...<br>(*b*) By reflection of sunlight from shiny material ... ... ... ... | | | |

N.B.—1–6, refer to general conditions in room. 7, 8, refer to spot where accident occurred.

our Society with the insurance companies, and those, like factory, tramway and railway managers, who are directly concerned with traffic. It is a good example of the kind of investigation that calls for joint effort.

While compiled mainly for accidents in streets and factories, these tables could, with a little adaptation, be applied to railways (both as regards the lines and repair shops, &c.). Accidents on railways form an important class, and as the chief companies already possess comprehensive schedules of data on the subject, a very little extra work would yield useful information in regard to lighting.

Insurance companies concerned with accidents, both to men and machinery, have a special interest in this question. Once the relation between defective lighting and accidents is appreciated, the next step to be taken would be for insurance companies to offer more favourable terms to those employers whose premises are well lighted, and where, therefore, the risk of accidents is correspondingly diminished. That this practice would be profitable to insurance companies is illustrated by the fact that it is already adopted in regard to fire risks, premises equipped with sprinklers and other preventive devices receiving more favourable treatment as regards terms than those which are backward in this respect.

**The Prevention of Blindness.**

Having referred to various accidents, traceable to bad illumination and occurring in industrial life, we may next note one particular case of the relation of illumination to health—its effect on eyesight.

The importance of good lighting in relation to the eyesight of school-children and of adults in factories has often been emphasised, but the broader question of its effect on the eyesight of the nation is one that should not be overlooked. It has been suggested that the care of the blind, and the prevention of blindness, are matters that should fall under the care of the State. A very full report on this subject was recently issued by the Departmental Committee on the Welfare of the Blind, in which the establishment of a fund of £500,000 at the disposal of a new Central Authority to deal with the Education and Welfare of the Blind was suggested. Among other points mentioned in the Report are the need for a careful statistical inquiry into the causes of blindness, and for schools for the separate treatment of myopic and partially sighted children. The strain put upon children's eyes in infants' schools, particularly the reading of small print, is mentioned as a contributory cause of blindness, and it seems obvious that the lighting of such schools, and particularly those schools allotted to children who already show signs of short sight, should receive special care. While we should welcome statistical data on this subject there can be no doubt that inadequate lighting adds very greatly to the strain of school work, and is therefore conducive to defective sight.

Unfortunately, the number of blind persons in the United Kingdom is considerable, namely, 33,965, or 1 in 1,274 of the whole population. It is noteworthy that over 30 per cent. of the blind population are in receipt of poor law relief, and though much might doubtless be done to alleviate their lot and render a larger proportion self-supporting, the economic loss to the country, through more or less grave defects of vision, must always be great. An exhaustive inquiry into the origin of blindness and defective vision would be fully justified by its beneficial results, and we would like to see the question of the effects of poor lighting included within its scope.

**Conclusion.**

While there are many other developments which have been inevitably checked by the war, we hope that the time is not far distant when these normal fields of operation will be resumed.

At present it is naturally impossible to give details of the many special applications of light in connection with the war. Several of these, such as the use of light-giving compounds in flares and star-shells, the application of radium paint to gunsights, &c., were mentioned in the Presidential Address. But the design and use of searchlight projectors of various kinds, the special uses of light for aircraft landing places, in military camps, and on board ship, form an interesting chapter in illuminating engineer-

ing. Naval and military operations must now be carried out both by day and night, and essentially depend on the vision of the combatants, and the use of light to reveal the objects viewed requires the most assiduous study. Of these points, a most fascinating account may be given in the future.

There will doubtless be many problems of interest to the Society in connection with the reconstruction proposals after the war. Large areas will have to be rebuilt and towns planned, and in all such work there should be a quite exceptional opportunity for designing the lighting on the most modern plan. In another field, the use of lighting for spectacular and advertising purposes, there is also much to be done. Even before the war, the desirability of restrictions of brilliant advertising signs was under consideration, and the experience gained in the present conditions should tend towards some control, even in peace time, of the display of light in public thoroughfares. More artistic and efficient devices, such as those depending on "flood-lighting," will no doubt be introduced, and similar methods may be applied to the illumination of the exteriors of public buildings and monuments, in exhibitions, and for other special decorative purposes.

In this paper a few of the possible future developments of illuminating engineering have been indicated. In a complete study of illumination we have not only to deal with *the cause*, the lamps and fittings by which light is distributed, we have also to study *the effect*, hygienic, economic, and artistic. The latter section of our work will now command special attention and will involve co-operation on a wide basis.

I have indicated a few of the ways in which our aims in this respect could be achieved. But there is one other channel for the dissemination of information on illumination which must not be overlooked—the scientific, technical, and daily Press. From the commencement of the movement it has been a great advantage to the Society to have a journal of its own for the conveyance of such information, but the sympathetic way in which our work has been received by other journals, and the full publicity that they have given to our discussion of papers and conclusions arrived at, has been of very great value in spreading a knowledge of our aims and objects in many quarters which could hardly have been reached otherwise. Let us trust that these cordial relations with the Press will continue to operate in the future as in the past.

By the aid of all these channels of communication—with the State, with other societies and industries, and with the Press, illumination will no doubt come to occupy an even more important position than it has hitherto done. Illuminating Engineering knows no barriers. The stream of progress, even in the present circumstances, is not blocked, but only diverted, and when the opportunity comes to resume all the varied aspects of our work in freedom, we shall find abundant opportunities for new service.

## *DISCUSSION.*

THE PRESIDENT then invited discussion on Mr. Gaster's paper.

Mr. E. WILLIS (Engineer and Surveyor, Chiswick Urban District Council; Vice-Chairman of the Street "Safety" Committee of the London Safety First Council) said that he had been much impressed by the suggestions made in the paper regarding the tabulation on a uniform basis of data regarding street accidents. There was one slight addition he would suggest, namely, the inclusion of the height of the lamp in the vicinity of the spot where the accident occurred.* Particulars on this point were desirable because the angle at which the light was thrown on the object causing the accident, or on the victim of the accident, was a very important item.

The presentation of such information in a form that could readily be utilised, as suggested by Mr. Gaster, would be a most useful achievement, and it should be the aim of every municipal engineer

* This suggestion has now been carried out.—ED.

and lighting expert to bring this about. From his experience he knew the difficulty of moving Government Departments, and recognised that in such cases as this much persistence was needed. But at the present time he believed that the Government was fully alive to the importance of adequate street lighting and he thought that representations made in the proper quarter by the Illuminating Engineering Society and other bodies interested would receive sympathetic consideration. He himself had supported Mr. Gaster's suggestions at meetings of the London Safety First Council.

In general the ordinary layman was not a suitable person to undertake the tabulation, or at least the analysis of such information, but the Society and the London Safety First Council would no doubt be prepared to give the necessary expert guidance.

In regard to factories he was also in sympathy with the principles laid down in the paper, and the information to be recorded in the Tables appeared most useful. As the Education Architect in his district, he had occasion to study both natural and artificial lighting conditions in the schools. While he knew that there were in existence portable illumination-photometers for use in such work, he thought there was room for improvement in the direction of evolving a simpler type. Such an apparatus would be extremely useful in ensuring that the room was properly illuminated, especially on dark and foggy days. Under such conditions the children suffered from headache and lassitude, the work depreciated, and the teachers were apt to become irritated because the children did not work well. It would be a great help if some form of registering apparatus could be stationed in each school and readings taken regularly and reported to the official responsible for the lighting, who would then be in a better position to take steps to remedy any defects. He concluded by expressing his personal thanks to the author for the admirable paper to which he had listened with much interest and to the Society for the privilege of attending and being allowed, although only a visitor, to join in the discussion.

COUNCILLOR H. NEWTON KNIGHTS, J.P. (Chairman of the Publicity Committee and member of the Street "Safety" Committee of the London Safety First Council), expressed his agreement with the suggestion made by Mr. Gaster that data should be collected showing the relation of street-darkening to accidents. If the Home Office could be approached and their sympathetic co-operation secured very useful results should follow. As one responsible for 14,000 street lamps he appreciated how valuable it would be to have such statistics presented on a uniform basis and he wished to congratulate the Society and Mr. Gaster on having taken the matter up. It was largely through Mr. Gaster's efforts that the improvement had been made in the street lighting of London early in 1917, the object then being to secure, so far as possible, uniform lighting conditions throughout the entire London area.

When he, with other representatives of local authorities, attended at the Home Office to discuss the lighting arrangements it was pointed out that it was impossible to conceal completely a large city like London by any modification in the lighting arrangements. On a clear night London could be picked up from a considerable distance and even in a dense fog it had been located, though naturally not from so far.

It was evident therefore that there were limitations to what could be achieved by diminishing the lighting. It was desirable to diffuse the light, and it was inadvisable to have the full light available in the lantern and then to block out all but 5 per cent. of the rays, leaving a small bright patch of light, with adjacent regions of the street in deep shadow. The latter condition was very liable to cause accidents, but if severe contrasts could be eliminated and general diffused lighting provided. this would have a most beneficial effect

He sincerely hoped that the information suggested by Mr. Gaster would be obtainable and he felt sure that the London Safety First Council would be only too pleased to be of assistance in furthering the aims that he had in view.

Mr. R. P. HOWGRAVE-GRAHAM referred to the problem of introducing to technical students modern ideas of illumination which involved not only the subject of physics but a considerable amount of physiological knowledge. While at present few students would become illuminating engineers, all, whether associated with mechanical or electrical engineering of chemistry, ought to have a general knowledge of the subject, which would be of considerable value to them as managers of works, etc.

It might be desirable for the Society to consider how the subject could best be presented to unspecialised men. His method had been to lay stress on such obvious fundamental points as the screening of lamps, the effect of light on the eyes, and simple calculations of illumination, and to impart a broad knowledge of the ideas underlying the chief systems of lighting. A distinction should be drawn between specialised courses in illuminating engineering, which must of course be thorough, and those designed to help men to deal with lighting problems incidental to their respective vocations. As regards the tables presented relating to the effect of illumination on accidents, he thought that the particulars should be filled in under expert guidance, and should be available to an authority with powers resembling those of the Board of Trade investigators in the case of railway accidents. While not wishing to impair the simplicity of the tables he thought that some further subdivision would be desirable. For example it should be stated whether the lamp utilised low or high pressure gas, or whether electric lamps were vacuum or gas-filled lamps, etc. Even some rough expression of the candlepower in relation to the angle at which the ray was received might be included.

As regards outside lighting he ventured to hope that in view of the prospective need for economy in fuel supplies the future would bring compulsory restraint in the use of advertisement lighting. It might be difficult to draw a distinction between legitimate and wasteful illumination in the case of shop windows but the extravagant expenditure of light on pure advertisement was surely unnecessary.

In regard to the projected developments in supply stations he recognised the gain in efficiency that might be secured, but there was also the possibility to be guarded against that the concentration of supply facilities in a few very large stations might have grave results in the paralysis of extensive areas if one of these should be put out of action, either by aerial bombardment or through any other cause of breakdown or destruction.

Mr. E. M. GRANT remarked that the question of illumination in the factory was often determined purely on cost, and it was still necessary to educate the factory manager and proprietor to appreciate the value of good illumination in relation to the work done. Supply companies in general had few opportunities of getting in touch with consumers. The price quoted by electrical contractors was usually a determining point and it was desirable that they, too, should be armed with information illustrating the advantages to be gained by proper methods of illumination.

THE PRESIDENT, after referring to the wide ground covered by Mr. Gaster's paper, remarked that consumers had often whims and ideas of their own in regard to illumination and were apt to resent suggestions in regard to domestic or industrial lighting. The conception that some illuminants " were bad for the eyes " would be found to rest mainly on the unintelligent manner in which they were used, and this would, by degrees, come to be generally recognised.

There were many methods of approaching the factory manager. One was to impress on him the desirability of avoiding accidents due to bad lighting, and in this direction the Home Office Report would have a useful influence. It was, however, desirable that the information in such Reports should be conveyed in a readable form, and within a small compass, in order that they might be appreciated by the general public.

It should also be impressed on the factory manager how small a proportion of his total expenditure was involved in lighting. Those who had visited some

of the new munitions factories would no doubt agree that the provision of satisfactory lighting was not a difficult matter and formed a very small item of cost both as regards the equipment of the factory as a whole and the working expenses.

Turning to the question of education in illumination THE PRESIDENT agreed with the desirability of elementary teaching on illumination in the curricula of technical colleges, either as a part of physics, optics or, in a broader way, in courses on engineering. Much might be done in this way to develop an interest in lighting on the part of students and encourage them to pursue the matter further afterwards.

Finally there was the very important question of the tabulation of information relating to street accidents, on which more expert guidance was needed. The Board of Trade in dealing with tramway accidents obtained a considerable amount of information, even on accidents of a relatively trivial character; such accidents were all reported by the tramway owners. Drivers and conductors had usually a great deal to do at the time of an accident and it was therefore desirable that any forms that they might have to fill up should be of a simple character, relating to information which was readily accessible, and that any technical data required should be obtained by supplementary assistance. Local authorities were in a better position to deal with the subject because, when accidents occurred frequently after dark in a certain spot, this would suggest the desirability of an inquiry into the lighting.

The second and third tables dealing with factories would, he thought, be the more easy to apply. The present moment was opportune for such work seeing that so many factories were in the hands of the Government and by a stroke of the pen much might be done.

As to the simple photometer for use in schools, suggested by Mr. Willis, he thought that this suggestion should not be a difficult one to carry out. He was in complete accord with the remarks of Mr. Howgrave-Graham on the subject of extravagant use of light for advertisement signs and would be glad to see them dispensed with in the future.

Mr. L. GASTER in reply expressed his appreciation of the sympathetic remarks of Mr. Willis and Mr. Newton Knights. The assistance of the London Safety-First Council would be extremely welcome, and that body had already done a great deal to promote better lighting conditions in London. He hoped that after the war this beneficial influence would be exerted even more strongly. He fully recognised the need for dealing with all essential points in the tables, without impairing their simplicity and would introduce into them the details suggested by Mr. Willis and Mr. Howgrave Graham, so far as the space available allowed.

The President had referred to the need for presenting technical information conveyed in Government reports in a readable form; it was largely with a view to this that a short readable summary had been issued with each copy of the Report on Lighting in Factories and Workshops, a course which he believed was adopted on this occasion for the first time in regard to Government publications. It was also desirable that when such Reports appeared their recommendations should be taken up and studied, and presented in a popular form to factory managers, and this was the kind of work that the Illuminating Engineering Society endeavoured to do.

He agreed with Mr. Howgrave Graham that the method of imparting information in technical colleges on illuminating engineering required study. Probably the first step would be to introduce instruction on fundamental points in the way he and the President had suggested. If this were done throughout the country the effect would soon be felt and complete courses in illuminating engineering would follow in due course.

As regards the extravagant use of light for purposes of advertisement he thought that after the experiences of the war people would be willing to submit to reasonable restrictions in this direction.

He hoped that in the future the whole of exterior lighting in cities would come under supervision, and that an attempt would be made to survey the complete problem and ensure that all light outdoors, as well as indoors, was used in the most efficient way.

# A SERIES OF TYPICAL MESSAGES TO THE SPECIAL "TEN YEARS' ANNIVERSARY NUMBER" OF THE "ILLUMINATING ENGINEER."

IN this section we reproduce a series of typical letters congratulating the *Illuminating Engineer* on attaining its Ten Years' Anniversary.

They include messages from the leading experts on lighting in various countries. Naturally, foreign nations are not so fully represented as would be the case under normal conditions, when many of the corresponding members of the Illuminating Engineering Society in different parts of the world would doubtless have participated. It is evident, however, that the claims of good illumination are very widely recognised. Amongst others, letters have been received from well-known scientists, physicians, inspectors of schools, librarians, and representatives of the lighting industry, all of whom refer in sympathetic terms to the work done by the journal during the past ten years. It is pointed out that there never was a time when the study of illumination was more important than it is at present, that illuminating engineering has many opportunities alike in peace and war, and that a wider knowledge of the principles of good illumination is a matter of national importance.

While deeply appreciating these tributes to the value of the *Illuminating Engineer*, and the many courteous references to the Editor's personal associations with illuminating engineering in this country, we value especially the illustration they provide of the relations of the movement to all sections of the community and the record they afford of results actually attained during the last ten years. Our chief desire in publishing this series of messages, is that they may lead many others to associate themselves with the work of the Illuminating Engineering Society, and its aim of developing the utilisation of light for the welfare of mankind.

# A SERIES OF TYPICAL MESSAGES TO THE SPECIAL TEN YEARS' ANNIVERSARY NUMBER OF THE "ILLUMINATING ENGINEER."

## PRESIDENTS AND PAST-PRESIDENTS OF THE ILLUMINATING ENGINEERING SOCIETIES IN ENGLAND AND THE UNITED STATES.

*Presidents :—*

**Mr. A. P. Trotter** (*President of the Illuminating Engineering Society*, LONDON):—

Allow me to congratulate you on the completion of ten years of the *Illuminating Engineer* which you had the courage to found in anticipation of a demand, the enthusiasm to develop on scientific lines, the skill to balance between competing interests, and the satisfaction of producing in so successful and attractive a form.

**Mr. G. E. Stickney** (*President of the Illuminating Engineering Society*, NEW YORK, *U.S.A.*) :—

In congratulating the *Illuminating Engineer* on its ten years of service, it is fitting to mention the new bond which has been forged between the British and the American illuminating engineers in the past year by the entrance of the United States into the war. Not only has the suppression of the natural feelings due to requirements of neutrality been removed, but the stimulation of common aims and problems has welded our sympathies. In the past the American illuminating engineers have looked upon themselves somewhat as pioneers in lighting matters, although receiving many valuable ideas from our contemporaries across the ocean. In respect to the war lighting problems we realise more especially the importance of being guided by the experience of England and France. Thus the contribution of the *Illuminating Engineer* with its records of the British Illuminating Engineering Society has assumed special importance.

Realising that the proper application of illumination will enhance the country's power in every activity, the Illuminating Engineering Society in this country has vied with all other engineering societies in putting its service at the disposal of the nation. Not only have the members as individuals extended their co-operation but the Society has been fortunate in finding many opportunities for serving as an organisation. Several committees, of which one of the most important was especially constituted for the purpose, are bringing together, in intensive service of the Government, experts from all branches of the industry, including competing interests. Furthermore, the educational forces of the Society have endeavoured to forward industrial and protective lighting of both public and private works, so as to ensure the fullest possible supply of munitions.

We are still conscious, however, that the importance in illumination in increasing the national effectiveness is not yet generally realised. Recognising our obligation in this connection, the Society is constantly seeking to bring about a better appreciation of the relation which light and lighting hold to all phases of the war's activities. In this we are undoubtedly following the precedent established by the British Illuminating Engineering Society, and adopting some of their methods to our conditions.

With such common problems and sympathetic interests let us hope that our co-operation may be even more close than in the past; that we may contribute the greatest possible benefit to our several Governments and the cause of democracy as well as the important art which we serve.

*Past-Presidents :—*

**Dr. Louis Bell** (*Consulting Engineer*, BOSTON ; *Past-President of the Illuminating Engineering Society, U.S.A.*) :—

You deserve the heartiest congratulations on the decade's work of the Illuminating Engineering Society, and the record that the *Illuminating Engineer* has made during that period. It certainly is a monument to the development of the new art, which has grown in the face of manifold discouragements and taken a secure place in the work of the world.

I particularly desire to pass up compliments on the game way in which the Society and its organ have grimly stuck on the job, without wavering or grumbling, and have pulled success out of impending discouragements. We in this country are just beginning to feel the pressure of war, but from my viewpoint illuminating engineering is thereby rendered all the more necessary. If there was ever a time to make two lumens grow where but one was before, that time is right now. Difficulties in fuel transportation have hit hard some of the electric companies, and all are beginning to realise the need of economising energy. I know of no better way in which this can be done than by its more skilful use in the production of illumination, thereby saving for the industrial needs, which are growing at a rate which you probably can realise better than we can.

Personally, I have been particularly interested of late in the development of automobile headlight illumination, to which activity we are impelled by the passage of laws in many States, requiring not only the abolition of glaring illumination, but its redirection in a somewhat specific way. Twenty States now have laws requiring the abolition of anything like glare above forty-two inches from the ground at a distance usually seventy-five feet ahead of the car. Coupled with this, rather commonly, is a demand for light enough to reveal any substantial object on the road at a distance of one hundred and fifty to two hundred and fifty feet ahead of the car, and, not infrequently, requirement of good sidelight, extending ten feet on each side of the car at a distance of ten feet in front thereof. To meet these conditions and secure a first-class driving light that covers the road involves a very pretty problem in applied optics. Something like a thousand devices for modifying the light in one way or another have been proposed. A few score are on the market but you can count on the fingers of one hand those which are the result of scientific design. The best of them do a very workmanlike job, however, and I have no doubt that when Fritz quits his bombing expeditions you will feel the same need for the control of glare that we have found here, and will get the benefit of the experience already acquired.

It is interesting to note that the few successful devices are divided among the prismatic type adapted to depress and redistribute the beam, and skewed reflectors designed to accomplish the same purpose. Incidentally several of these appliances might be very usefully employed at the front for picking up and holding under observation a fairly wide spread of trench, or in sweeping for aerial raiders.

**Sir William Bennett, K.C.V.O., F.R.C.S.** (*Past-President of the Illuminating Engineering Society*, LONDON) :—

Congratulations upon the success attained by the *Illuminating Engineer* at the end of its first ten years of life.

As the official organ of the Illuminating Engineering Society, which is doing such good work of national importance, it seems to me to be an example of exactly how a publication of its kind should be conducted in dealing with a subject of steadily increasing moment.

The lighting question seriously concerns the community at large and the *Illuminating Engineer* stands for everything in the way of economy and efficiency connected with it, whether domestic or otherwise.

**Dr. E. P. Hyde** (*Nela Research Laboratory, National Lamp Works of the General Electric Co.*, CLEVELAND, Ohio; *Past-President of the Illuminating Engineering Society, U.S.A.*):—

Your journal has rendered valuable service, and I wish to you personally and to the journal continued well-being and success in the future.

**Dr. A. E. Kennelly**, (*Director of the Department of Electrical Engineering, Massachusetts Institute of Technology; Past-President of the Illuminating Engineering Society, U.S.A.*):—

My attention having been drawn to the fact that the *Illuminating Engineer* is about to complete its first decade of publication and service, I beg to present compliments and felicitations appropriate to that event. Illuminating Engineering has an importance for the world, both in war and peace, which is often unintentionally underestimated.

Our world is illuminated half the time by the sun, and also, on a greatly reduced scale of intensity, by the moon; artificial illumination is needed for an average of something like one-third of all the time. . . . The economic, hygienic, and æsthetic importance of artificial illumination are thus enormous to all the inhabitants of the globe, and especially to those in regions remote from the Equator.

Whereas our best rotating dynamo-electric machines have an efficiency of about 95 per cent., the efficiency of our best tungsten light sources is still in the neighbourhood of 1·5 per cent., if we take the most recent determination of the mechanical equivalent of light, viz., 1 watt equivalent to 617 lumens. Consequently, while it would be a physical impossibility to increase the efficiency of the best dynamos more than a few per cent., it should be possible somehow to increase the luminous efficiency of lamps many times. In this direction the period of publication covered by the *Illuminating Engineer* has witnessed a notable progress, and the path is still open for yet greater achievements, to let our "light so shine before men." . . .

**Mr. L. B. Marks** (*Past-President of the Illuminating Engineering Society, U.S.A.*):

I note that next month you will celebrate the tenth anniversary of the *Illuminating Engineer*. Please accept my hearty congratulations on this occasion and my best wishes for the continued success of your journal.

It is hardly conceivable that any journal covering the wide field that is encompassed in the broad subject of illuminating engineering could measure up to the standards of all its readers. To do this would be expecting too much, especially when its readers consist of trained engineers; architects; physicists; physiologists; manufacturers of lamps, lighting fixtures and accessories; salesmen; draughtsmen, etc. etc. Considering the difficulties you have encountered you have done remarkably well and are entitled to the thanks not only of the members of the community especially interested in lighting, but of the public as well.

You have consistently lived up to the standards which you yourself have laid down, namely impartial treatment of all illuminants, dissemination of up-to-date information on problems connected with artificial and natural lighting, and advancement of the lighting art in the interests of health, safety, economy and efficiency.

I am not at liberty to say much regarding the special problems which the Illuminating Engineering Society in this country has been called upon to handle in connection with the war. . . . I have been serving on the National Lighting Committee (now known as the Divisional Lighting Committee of the Department of Labour, Council of National Defence), the War Services Committee of the Illuminating Engineering Society, and the new Committee of Technical Societies which is now serving under the Naval Consulting Board.

In connection with your suggestion for more complete co-operation between lighting experts in different countries I heartily favour such a movement and believe that the vehicle for carrying it out already exists, namely, the International Commission on Illumination.

**Mr. Preston S. Millar** (*Technical Director, Electrical Testing Laboratories,* NEW YORK; *Past-President of the Illuminating Engineering Society U.S.A.*):—

It is a pleasure to extend congratulations to the *Illuminating Engineer* on the completion of ten years of unique service to the cause of good illumination. In the capacity of a journal, and later as the organ of the Illuminating Engineering Society, the *Illuminating Engineer* has done much to knit together the propaganda for good illumination in England and in America. It has made known to leaders of the art in this country the deliberations of English specialists in this field, and through careful reviews of American literature it has probably accomplished a like service in England. It seems probable that the illuminating engineering movement is materially stronger by reason of the *Illuminating Engineer* than otherwise it would have been.

These parlous times have brought home to Americans so much of British character and British achievements which is admirable that it may not be out of place to express admiration for the plucky way in which the *Illuminating Engineer* has continued to lift its voice in favour of effective illumination in war as well as in peace. This constitutes an additional reason why we in America have pleasure in greeting you on this occasion and wishing you a continued career of success.

**Dr. Clayton H. Sharp** (*Technical Director of the Electrical Testing Laboratories,* NEW YORK; *Past-President of the Illuminating Engineering Society U.S.A.*):—

Let me congratulate you most heartily on your success in conducting the *Illuminating Engineer* through the first ten years of what I hope will be a long and continuously useful life. You have been doing through the *Illuminating Engineer* a most valuable work. The magazine has always been not only useful but readable, and has held a position in the foreground of progress during a series of years when progress in illuminating engineering has been particularly rapid. You have chronicled events and ideas impartially without regard to the country of their origin. . . . You have been a very important factor in promoting international understanding among illuminating engineers.

Among the regrettable results of the war has been the cessation of international activities which were so auspiciously begun at the 1913 meeting, where the International Commission on Illumination was formed. At that time there were really two worlds—the Germanic world and the rest of the world, and no provision was made for the contingencies such as have arisen. As things are, however, there would seem to be no very valid reason why the rest of the world should cease its endeavours to come to mutual agreements and understandings simply because Germany has seen fit to secede from civilisation. The machinery for promoting international contact was provided at the 1913 meeting and fortunately still remains in the hands of the great majority. The rest of the world has succeeded in doing a great many things, not only without Germany but in spite of Germany's more or less vigorous resistance. Why cannot illuminating engineers, using the machinery which is available to them, go on with their work of international standardisation, even if only in a manner which is necessarily restricted by the conditions of the times?

The United States National Committee of the International Commission on Illumination has been kept intact; the Illuminating Engineering Society has continued its activities, particularly its Committee on Nomenclature and Standards has been proceeding with the work which it has in hand, and material is ready in this country, as no doubt it is in your own, for eventual international consideration. I express the hope that the *Illuminating Engineer* will agree that something might be accomplished along these lines if only to the extent of preparing for real progress when the war is over, and that it will grant its influential support to this idea which I know represents the thought of those in this country who are most closely in touch with the situation.

## GENERAL, SCIENTIFIC AND INDUSTRIAL ASPECTS OF ILLUMINATION.

**Sir William Crookes, O.M., F.R.S.** (*Vice-President of the Illuminating Engineering Society,* LONDON):—

I am very glad to have the opportunity to express my appreciation of the *Illuminating Engineer.* It is always full of interest. The national importance of a clear knowledge of the laws of light with special reference to illumination is unquestionable. The subject is a very large one embracing not only natural and artificial light but also the effects of it upon the eye.

For several years I have been engaged upon the preparation of light filters and eye-preserving glasses, a problem second only to the production of light itself in importance, and I am glad to have seen that this phase of the subject has not been neglected in the pages of the *Illuminating Engineer.* I wish the journal every success.

**Professor C. M. Gariel** (*Professor of Medicine and President of the French State Committee on Illumination*):—

I have always read the *Illuminating Engineer* with great interest, and I think that in the course of my regular perusal of your journal there has scarcely been a copy which has not contained something giving rise to reflection on some point of importance. . . .

I should like to say how greatly I regret that we have not in France a Society such as the Illuminating Engineering Society, and in a position to deal generally with the subject of illumination. There are so many points which, while in a measure related to various systems of lighting, nevertheless require independent treatment. One should, in fact, be able to determine in any given case the conditions which it is essential to fulfil, but should recognise that the requirements can be met in many diverse ways. The choice of the system of lighting in such a case appears to me a secondary matter, depending on local conditions, chiefly relating to cost. Only a few problems have been studied from this standpoint in France, and I know scarcely any, except in regard to the lighting of schools, for which some recommendations have been made.

As you conjecture, the war has led to conditions similar to those prevailing in your country; as in England restrictions have been applied, especially to public lighting. In the latter case, the restrictions appear to me to have been carried out in a haphazard manner, although it would have been interesting to ascertain, by a comprehensive study, how, with a given consumption of gas or electricity, one could obtain the most satisfactory conditions of illumination in public streets.

I have had no experience—and I believe that except in special services, they do not exist—of regulations relating to the lighting of factories devoted to war work. We have here an analogous problem, namely, to determine in each case the provision of adequate illumination at a minimum cost. In view of the large number of such factories the question is of considerable importance. The conditions, however, as regards lighting are broadly similar to those applying to factories in time of peace.

Such problems ought to be the subject of careful study on the part of illuminating engineers, and for this reason I consider it highly desirable that there should be established in France a body of specialists in this work.

I do not profess to have been the first or the only one who has given expression to these views, but in replying to your inquiry I have endeavoured to state them in a concise form.

**Professor A. Vernon Harcourt, F.R.S.** (*Hon. Member of the Illuminating Engineering Society,* LONDON):—

. . . I greatly admire your personal work, the industry and energy with which you have conducted the Illuminating Engineering Society and edited its Journal.

**Mr. M. Luckiesh** (*Nela Research Laboratory, National Lamp Works of the General Electric Co.*, CLEVELAND, Ohio, U.S.A.):—

During the first years of the war we, in the United States, have watched and admired, from a position of comparative security and comfort, the struggles of those who were fighting the battle which is now ours as well. . . . Our appreciation of the efforts of the *Illuminating Engineer* in the humanistic cause of proper lighting, to which all lighting people have been called allied in times of peace, can only be excelled by our appreciation of the spirit which has enabled your journal to endure the tribulations of war times, and to do your part towards winning this tremendous struggle for the right to live in peace.

At this tenth anniversary of the *Illuminating Engineer* it is a pleasure to look away from the stern duties of war momentarily in order to express a word of appreciation to you for the efficient work your journal has done; and to encourage your colleagues and ourselves with the hope that our devotion to the cause of proper lighting will not only continue during this dark period, but will emerge stronger and more determined to meet greater needs of the post-bellum period. In fact, our lot seems always to be one of opportunity.

May we look forward to the coming day when we can shake off the impediments of war and, with the added impetus of renewed freedom, again direct all our efforts toward the conservation of vision, and toward the increase in the safety, the efficiency, and the happiness of mankind.

**Mr. W. M. Mordey** (*Past-President of the Institution of Electrical Engineers*):—

Hearty congratulations to the *Illuminating Engineer* on its ten years of work, during which, it seems to me, the Science, the Art and the Industry of Lighting have been put on a firm foundation by the Illuminating Engineering Society, its Journal, and its Editor.

May that very useful work continue with growing success.

**Sir David Murray, R.A.**:—

I congratulate you on the great usefulness of your journal now really established by its tenth year of issue and wish it long life to continue in its good work.

The proper illumination of picture galleries, studios and private houses is a much more important matter than is generally supposed, and gets far too little attention from qualified experts, as well as those who ought to be giving careful attention to it.

Many collections of masterpieces in art of all kinds make but little impression on those who view them, from the very imperfect lighting in which they are seen, and every improvement in this direction should be welcomed. There is no better means of doing this than by the journal you have so successfully edited.

**Sir Boverton Redwood, Bart.** (*Adviser to H.M. Government on Petroleum; Vice-President of the Illuminating Engineering Society, London*):—

I have always taken a keen interest in the work of the Illuminating Engineering Society, and I am fully aware how largely its progressive prosperity has been due to the *Illuminating Engineer*. Under your exceptionally able editorship that journal has long since occupied a high position in current technical literature, and is the accepted authority on the subject with which it deals. In no other way could the study and solution of the important scientific and industrial problems connected with illumination have been so effectively promoted and such satisfactory results achieved.

I have, therefore, the greatest pleasure in congratulating you most warmly upon the approaching publication of your decennial number, and in expressing the confident prediction that under your continued direction the *Illuminating Engineer* is destined to occupy an even higher place in the estimation of those most competent to appraise its merits than that which it has attained to.

**Professor C. S. Sherrington, F.R.S.** (*University Laboratory of Physiology, Oxford; Member of the Home Office Departmental Committee on Lighting in Factories and Workshops*) :—

The issue of the decennial number of the *Illuminating Engineer* is an event which physiologists will welcome as a matter of congratulation to its management and to the Illuminating Engineering Society.

The happy combination of scientific and practical view which has characterised the journal throughout has done something to enlist the greater interest of physiologists generally in problems of illumination. I remember meeting the first number of the *Illuminating Engineer* on a railway bookstall at Liverpool. It impressed me by its sympathetic reference to the value of physiological and psychological studies for the objects it had in view. It heralded a salutary change from the watertight compartments system of dealing with technical research. It offered a medium through which physicist and chemist and biologist might gain mutual contact in their promotion of practical aims. One of its initial objects was to bring specialists in various fields in touch with one another, and to acquaint readers with the aspects of all specialist researches regarding illumination.

As a physiologist I endorse, sincerely and regretfully, the words of the President of the Illuminating Engineering Society, given in the December number, 1917 : " More work is wanted, or, at all events, more accessible literature is needed on the physiology of vision." As regards the latter point, I may mention that the Physiological Society now issues, with the co-operation of the American Physiological Society, a monthly international " literature list " for physiology, styled *Physiological Abstracts*, containing abstracts of more than 3,000 physiological papers a year, and embracing all the investigations dealing with the physiology and the psychology of vision. The President's address continued : " The dioptrics of the eye are well understood ; its normal, abnormal, and pathological characteristics are the bases of ophthalmic science," and then he went on to point out the defective state of physiological knowledge of certain features of vision of high interest for the hygiene of illumination problems.

That these problems are difficult of investigation is, I think, only part of the reason why not more progress has been made in regard to them. Physiologists as a body are not very fully aware of the urgency for the study of them, and the measure in which researches by psychophysiological methods might contribute help. To keep calling attention to the need for their investigation, and to put any such progress as may be made in regard to them before its readers is, it would seem to me, not the least of all the various useful functions which the *Illuminating Engineer* fulfils, and has fulfilled, in the public interest as well as the technical, for these first ten years since its inception.

May I conclude my tribute to its management and utility by wishing it all success in continuing to do so in the future.

**Mr. Sydney Walton** (*Ministry of Food*) :—

I wish to congratulate the *Illuminating Engineer* on attaining its tenth birthday. Caxton was in my judgment, the lamplighter of our intellectual streets by his invention of the printing press.

The printed word in the *Illuminating Engineer* is doing much towards advancing the science and movement which it expounds.

**Mrs. Sydney Webb** :—

The distinguishing characteristic of the Illuminating Engineering Society is its constitution. The great majority of professional organisations and technical societies are made up of members of one particular vocation—of medical men, of teachers, of architects, or of engineers. The great drawback of this kind of organisation is a tendency on the part of the members to object to new forms of knowledge—possibly the technique invented by another class of brain-workers. In such an atmosphere the most honourable men become the advocates of vested interests injurious to the community.

We can never trust the ordinary professional organisation to be wholly impartial with regard to new processes, new materials, and new men. The Illuminating Engineering Society has provided against this danger by introducing into its membership not only the brainworking producers of all forms of illumination, but also the expert representatives of the consumers of this service, whether these be other professionals, such as architects or ophthalmic surgeons or direct representatives of local authorities. The one test of membership is *expertness*, either in the production or in the consumption of the service concerned. So far as I know, the Illuminating Engineering Society is almost unique in this respect. Another great example of this interesting constitution is the series of sub-committees of the Engineering Standards Committee.

This remarkable constitution ought to become the exemplar of any Advisory Committees appointed by the Board of Trade to help in the re-organisation of industry after the war. It would be a grave national misfortune if these Advisory Committees were made up exclusively of professional men and profit-making employers who were financially interested in a particular type of industrial process or product, or the use of a particular kind of raw material. The inclusion of the expert representatives of the commodities concerned will alone prevent stagnation and corruption in our industrial organisation. It might be well for the members of the Illuminating Engineering Society to discuss this question with a view of promoting the adoption of their constitution for any Advisory Committee set up by the Board of Trade.

**Sir James Yoxall, M.P.** (*Editor of "The Schoolmaster;" General Secretary of the National Union of Teachers*):—

I wish continued and increasing success to the *Illuminating Engineer*. One of our national needs is a wider and yet a more technical interest in whatever makes for scientific and economic progress.

**Sir Henry Trueman Wood** (*late Secretary of the Royal Society of Arts; Vice-President of the Illuminating Engineering Society*, LONDON):—

Though I have always been opposed to the extreme multiplication of technical societies, I fully admit that the Illuminating Engineering Society has justified its existence. It has done a great deal to help in the solution of the numerous problems which have arisen in connection with lighting, both practical and scientific, since the development of the electric light, and its journal forms a most valuable record of progress in its own speciality.

Its success has been due largely to your own energy and perseverance, and you are to be congratulated on the manner in which you have secured the help of all the most accomplished experts in the science of illumination.

**Mr. C. H. Wordingham** (*President of the Institution of Electrical Engineers*):—

I respond with the greatest pleasure to your invitation to add my testimony to that of so many others as to the usefulness of the work accomplished by the Illuminating Engineering Society and its official organ, the *Illuminating Engineer*. Not only have they covered ground but imperfectly cultivated before they came into being and directed attention to the need for the study of efficient illumination as an art in itself, and provided the means for carrying out such study, but they have brought together those who, though labouring for a common end, had, in the past, found themselves ranged in opposite and, to a large extent, hostile camps. By providing a common meeting ground they have fostered that co-operation which is so beneficial to the members of allied industries and to the community at large.

I heartily congratulate the Society and the Journal on the progress made and the success attained in the first decade of their existence, and I would include in my congratulations your energetic self, to whose efforts the success is largely due.

## SCIENTIFIC AND TECHNICAL PRESS.

**Mr. E. J. P. Benn** (*Benn Bros. Ltd.*) :—

May I be allowed to congratulate you on having completed ten years with the *Illuminating Engineer*.

It must be a source of considerable gratification to you to be able to look back upon the tremendous progress that has been made in the art of illumination since 1908 and to know that the *Illuminating Engineer* and its distinguished editor have had such a large hand in its development.

**Dr. R. A. Gregory** (*Asst. Editor of "Nature"*) :—

Just as light is invisible until it strikes a material object, its many practical aspects were not revealed until your *Illuminating Engineer* provided a medium by which they could be reflected. I offer you my sincere congratulations upon the attainment of the tenth anniversary of the journal which has been of the utmost value to all who are interested in the subject of scientific illumination and has assisted so effectively in promoting the study of all matters relating to the production and utilisation of light.

The field is so immense that workers in different parts of it were widely separated, and they needed a common meeting place such as you have provided in your journal, which paved the way for the Illuminating Engineering Society, founded a year later. Problems and practical applications of illumination present themselves continually in the laboratory, the factory, the home, the school, and everywhere else where the conditions of good seeing are studied. By your efforts interest in the subject has been focussed; and scientific investigators, engineers, architects, teachers, oculists and other workers for exact knowledge and its efficient application, have combined to elucidate many important questions. For the persistent efforts to promote advance in this and all other directions, all who are concerned with the advancement of science and the industrial use of its data must be grateful. Your unbounded supply of kinetic energy fills me with wonder and admiration; and to it must be largely attributed the decided success which you have achieved.

**Mr. P. A. Gilbert Wood** (*Editor of the "Architect and Contract Reporter"; Fellow and Member of Council of the Institute of Journalists*) :—

Ten years is a small space of time, and yet how much can and does happen. Perhaps in no branch of industry has there been a greater advance than in illumination. Ten years ago practically no consideration from a scientific point of view was given to the subject. Your Society was founded and soon a change came upon the scene. Architects and builders have discovered that the specialist can offer suggestions, by means of which initial outlay and cost of current and gas may be reduced and the upkeep brought down to a minimum, without reduction of illumination. In the lighting of schools and public buildings a great advance has likewise been made, and I do not hesitate to affirm that you and your Society have much cause for gratification that your efforts have had and are still having beneficial results, which will be of lasting value to the community.

I trust that at the end of the next ten years you may be able to look back with as much satisfaction as you now must do upon the period which has passed.

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As an addendum to the above letters, we should also like to refer to an editorial article in the *Engineer* for January 24th, 1918, referring to the discussion before the Illuminating Engineering Society on January 15th.

It is remarked that "The Illuminating Engineering Society may look back on the past ten years with satisfaction, for in that period it has not only witnessed a striking improvement in the lighting of factories, houses and streets, but it has, by its own endeavours, done not a little to further that improvement and to put the art on a scientific basis. . . . The Illuminating Engineering Society, supported by its official newspaper, the *Illuminating Engineer*, has done good work in the past, and will . . . do even greater work in the future. . . . We wish it every success."

## LIGHTING OF SCHOOLS AND LIBRARIES.

**Mr. Herbert Cornish** (*The School Government Chronicle, etc.*) :—

On professional, personal, and general grounds it is very interesting to me to be reminded that the *Illuminating Engineer* has completed the tenth year of its editorial life.

Although I could not pretend to debate with your specialist readers the scientific and economic issues of the subject to which the *Illuminating Engineer* is devoted, my life-long and more or less concurrent service to some undertakings identified with Public Education, and with those kinds of literary labour which, more than others, are responsible for burning of the " midnight oil," has given me something more than ordinary respect for the work which you represent in technical journalism.

Therefore with great sincerity I offer you congratulations on your tenth anniversary and good wishes for an ever-ascending scale of future success.

**Sir Frederic Kenyon** (*Chief Librarian at the British Museum*) :—

I gladly testify to the utility of the work which during the last ten years has been done by the *Illuminating Engineer*. For those who have charge of Museums and Picture Galleries the problems of lighting are an increasing pre-occupation. On our part it is a duty to seek the best scientific advice obtainable; and we look to the engineers whom you represent to consider these problems from our point of view.

**Dr. James Kerr** (*Medical [Education] Officer to the London County Council*) :—

The *Illuminating Engineer* has now the record of ten years of strenuous work done. From the first it has taken up a leading position as a scientific journal independent of all interests other than those of spreading a knowledge of light. This advocacy of the best in work or play has commanded attention from all quarters. The knowledge of good lighting in house or street has added to the beauty and amenities of life and has also meant an enormous advantage to every eye-worker. Eye-saving is becoming an urgent sanitary measure especially in the schools, and such topics as lighting, shadows, prevention of glare and distress to eye-workers are of vital importance. Information on such subjects has been made accessible to those beyond the actual circle of technical workers through the columns of the *Illuminating Engineer*. It has started many movements yet destined to come to fuller fruition, and the next few years should give it greater fame.

**Dr. C. W. Kimmins** (*Chief Inspector of Schools to the London County Council*):—

I am very much interested to hear that the January number of the *Illuminating Engineer* will serve as a permanent record of the excellent work your Society has carried out during the past ten years. The members of the Cinema Commission were very much impressed by the ability and enthusiasm with which your Society dealt with the lighting of cinema theatres, as shown by the valuable papers and discussions at the meeting held in the House of the Royal Society of Arts, and also by the valuable evidence which you gave before the Commission. I sincerely hope that during the next ten years the work of your Society will be carried out with equal ability and enthusiasm.

**Mr. H. R. Tedder** (*Chairman of Council of the Library Association*) :—

I wish the *Illuminating Engineer* every success and hope that its career may be long and prosperous. Librarians ought to be grateful for what it has done to improve library lighting and I well remember your own special exertions in this direction. The question of the best form of lighting in libraries and for all reading purposes is one which is no less important to earnest students than to custodians of books.

## ILLUMINATION IN RELATION TO HYGIENE AND SAFETY.

**Mr. H. C. Blain** (*Joint Hon. Secretary of the "Safety First" Council*):—

In stating that the London "Safety First" Council appreciates the co-operation of the Illuminating Engineering Society, and the invaluable assistance rendered by its Hon. Secretary, Mr. L. Gaster, in the conduct of the London "Safety First" Campaign, and in expressing the hope that the *Illuminating Engineer* may, in the future, enhance still further its reputation and increase its sphere of usefulness, I feel confident that I am voicing the sentiments of every member and officer of the Council.

**Dr. L. Carozzi** (*Hygienic and Welfare Supervision Department, Ministry of Munitions, Italy*):—

Some years ago, in "Lavoro," I wrote of the work of the *Illuminating Engineer* and the Illuminating Engineering Society: "England must be proud of the success of an idea originated in London and now spreading throughout the entire world. But a few years ago Illuminating Engineering was a Cinderella among the sciences. Thanks to the enthusiasm with which engineers and hygienists in England have taken the matter up, international attention is now being concentrated on this question."

Now, in the special January number of your journal issued just ten years since the commencement of its work in England, I must applaud, with other workers in the field of illumination, the activity of your Society, the pioneer of a world-wide movement which has directed our attention and energy into new directions and led to the appreciation of the hygienic, economic and social benefits of good illumination.

We must recognise that some researches and investigations on Factor Lighting in Italy have received attention only after the campaign carried out by the Illuminating Engineering Society in London. We are indebted to you not only for the recommendations prepared on adequate and scientific illumination of schools, libraries and factories and for the study undertaken on the physiology of vision and care of the eyes, but also for the excellent work done in the field of general science, which, after the war, will no doubt place your Society in an important and successful position.

**Dr. T. M. Legge** (*H.M. Chief Medical Inspector of Factories*):—

FACTORY DEPARTMENT,
HOME OFFICE,
LONDON, S.W.

The pioneer work that the *Illuminating Engineer* has done during the last ten years has been of immense benefit. Without the prominence it gave to the need for efficient illumination in factories and workshops I do not think we should have had the appointment so soon of the Departmental Committee on Lighting in Factories and Workshops, of which you yourself are a member. I remember recommending to the Home Office that one of our staff with scientific knowledge should be associated with the Society, founded in connection with the *Illuminating Engineer*, in order that the proceedings as printed in the journal should be kept fully before us. That was done, and it is interesting to know that Mr. D. R. Wilson, the officer whom I recommended for the purpose, was appointed Secretary to the Departmental Committee. That Committee may therefore rightly be regarded as the direct outcome of the work of the *Illuminating Engineer*.

The war has brought home to us the importance of the part played by inadequate illumination in factories. As is stated in the little book, *The Health of Munition Workers*, published by the Stationery Office, "Bad lighting affects output unfavourably, not only by making good and rapid work more difficult, but by causing headaches, faintness, and eye-strain."

I have personally been impressed by the discomfort caused, especially in night work, by thoughtless disregard of proper shading of lights. In the weaving of dark material I found a number of young women whose slight errors of refraction were brought out by the glare and the close attention needed by the dark colour of the threads so that many of them had had to take to spectacles. Here and elsewhere examination of the workers by

an oculist secured useful result. Much remains to be done, however, on similar lines.

I remember in one factory where special care had been taken to secure the best method of illumination, special reference was made by the Works Manager to the articles which had appeared in your Journal.

I sincerely hope for the success of the Journal in the future.

**Sir Thomas Oliver, M.A., D.Sc., F.R.C.P.**:

I congratulate the *Illuminating Engineer* on having attained its decennium, and the Editor upon the high class character of the journal as the official organ of the Illuminating Engineering Society.

In this country the journal has done much to improve the lighting of factories, and thereby to diminish the number of accidents among workpeople. The relationship between imperfect illumination and accidents has been frequently shown in its pages. In my own work, the association of industry and hygiene, I have received considerable assistance from the high standard and the special nature of the literary contributions which have appeared in the *Illuminating Engineer*. In regard to the physiology of vision, there is yet much in which scientific opticians and your Society might be found working hand in hand.

Your Society has made a good start. I hope that the Journal will continue to discharge the important functions it has undertaken.

**Mr. D. R. Wilson** (*H.M. Inspector of Factories, now attached to the Ministry of Food*):—

I am very glad to know from your letter of January 28th that you intend to issue a special Decennial Number of the *Illuminating Engineer*, and willingly testify to the excellent work carried on by the Illuminating Engineering Society since its foundation.

At the time I first became interested in industrial lighting, the conditions were commonly far from satisfactory and, except by a few of the more progressive manufacturers, the value of good illumination in relation to hygiene, safety and output, was not generally recognised. By 1915, the latest year for which I can speak of my own knowledge, very great progress has been made, and improved methods either had already been adopted or were in contemplation.

With the rapid increase of interest in industrial questions this progress has perhaps been to some extent automatic, but that it has been conducted on sound and continuous lines has been largely due to the work of the Illuminating Engineering Society, which has exercised a beneficent and gentle pressure in the right direction without attempting to educate the public in advance of their capacity to learn.

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## TWO INDEPENDENT ENDORSEMENTS OF THE IMPORTANCE OF GOOD INDUSTRIAL LIGHTING.

It is also of interest to quote two recent authoritative endorsements of the importance of good industrial lighting.

In reply to a recent inquiry in the House of Commons regarding the work of the Departmental (Home Office) Committee on Lighting in Factories and Workshops **Sir George Cave** stated that *good lighting in factories and workshops is of great importance to the health of workers and for the prevention of accidents and has also a considerable effect on output.*

The other endorsement, to which reference is made in Dr. Legge's letter on p. 34, occurs in "**Health of the Munition Worker,**" a booklet issued by the Health of Munition Workers Committee (M.O.M.), p. 54:—

"*The results of inadequate illumination are damage to eyesight and personal health, various forms of domestic insanitation, accidents in factories and workshops, often accompanied by diminution in output of work and lack of discipline. Bad lighting affects output unfavourably, not only by making good and rapid work more difficult, but by causing headaches and other effects of eyestrain. Attention should be paid to the lighting of passages, offices, and the immediate surroundings of the factory, as well as the factory itself.*"

## GAS AND ELECTRICAL SUPPLY AND INSTALLATION WORK.

**Mr. Frank Bailey** (*Chief Engineer City of London Electric Lighting Co., Ltd.*) :—

In spite of the *Illuminating Engineer* having completed a decade of utility, it is gratifying to note that it shows no signs of decadence. Electric supply is cheap ; electric lamps are good ; a little money buys a lot of current and a little current produces much light. The gloom of the Victorian era will therefore be forgotten in the glorious illumination of the future, and I trust that the efforts of the Society in showing how this can be done will continue to receive the able and brilliant assistance of the Editor of the journal.

**Dr. Charles Carpenter** (*Chairman of the South Metropolitan Gas Company*) :—

I am sure that all those engaged in the supply of gas and electric energy must appreciate your efforts to increase and extend their information with regard to the important matters dealt with in the *Illuminating Engineer.*

**Mr. F. W. Goodenough** (*Gas Light and Coke Co.* ; *Chairman of the Executive Committee of the British Commercial Gas Association*) :—

The one feeling that the tenth anniversary of the *Illuminating Engineer* arouses in my mind is that of gratitude for the excellent way in which it has served the good cause of scientific illumination in this first decade of study and teaching in that field.

In the true spirit of gratitude, if we are to accept the cynic's definition, I will express the hope that it may long flourish and continue ever to give better and better service to the cause. I wish it the success it deserves.

**Mr. S. L. Pearce** (*Chief Engineer, Manchester Corporation Electricity Works*) :—

I have much pleasure in adding my small tribute to the very excellent work done by the *Illuminating Engineer* in advancing the study of scientific illumination, which I feel sure has already borne fruit in practice.

**Mr. W. R. Rawlings** (*Past-President of the Electrical Contractors' Association*) :—

I have always read the Journal with much interest and have received information of considerable value in carrying on the business in which I am engaged.

Until I took an interest in the work of the Illuminating Engineering Society and its Journal, I had no idea of the many advantages to be obtained from the study of illumination, as carried on by the Society, which has opened a new vista for the development of illumination from the contractor's point of view. I am confident that those outside the Society cannot appreciate the fascinating interest and profit which is to be found in the many valuable articles, especially the editorial by the Hon. Editor and Hon. Secretary of the Society (Mr. Gaster) or there would be few men engaged in the industry who would fail to be possessed of a regular copy of the *Illuminating Engineer.*

**Mr. Robert Watson** (*Chief Engineer, Corporation Gas Works, Doncaster*) :—

I congratulate you on the attainment by the *Illuminating Engineer* of ten years, service. Perusal of the volumes now completed reveals a wealth of information and data on illumination matters which is surprising in its variety, and satisfactory in its usefulness.

The existence of the Illuminating Engineering Society and its official organ, the *Illuminating Engineer*, has been amply justified by results ; and, further, by the fact that common ground has been provided for the friendly meeting of lighting practitioners whose interests not only differ widely but are in some cases in "spirited competition," as our much esteemed President, Mr. A. P. Trotter, recently remarked.

Personal experience of amicable interchange of views at Joint Committee meetings makes one glad to add this testimony.

I wish you and your staff continued success with the *Illuminating Engineer*, and the expansion of its sphere of activities when a concluded war permits the resumption of experimental research work.

## MAKERS OF LAMPS AND LIGHTING APPLIANCES; AND THOSE CONCERNED WITH THEIR TECHNICAL APPLICATIONS.

**Mr. S. H. Callow** (*Messrs. Siemens Bros. Dynamo Works, Ltd.*) :—

Upon completing ten years of existence, I have pleasure in congratulating the *Illuminating Engineer* on the good work already accomplished, and in wishing it every success for the future.

As you know, I have taken a personal interest in the Illuminating Engineering Society since its inception, having assisted you in your paper before the Association of Engineers-in-Charge in 1907, when it was first decided to found the Society.*

The Journal has consistently reported the proceedings of the Society in an able manner, and has from time to time supplemented such Reports with valuable contributions by expert authors concerning many problems connected with illumination. The publication is therefore in my opinion a very valuable record of the work accomplished by the Society, which is at the disposal of everybody interested in efficient lighting systems. During the period these two organisations have been in existence, lighting has been in a state of continuous development, and the meetings of the Society have provided an impartial platform for the discussion of various problems as they have arisen. The transmission of these expert opinions through the medium of the Journal has greatly benefited the trade and public, and its service has proved of exceptional educational value, reducing materially the task of manufacturers engaged in the production of suitable lighting materials.

Since the outbreak of war the work of the Society has assumed particular importance in connection with the lighting of munition works and factories engaged on Government work, many installations having been completed where production has been maintained at its maximum during the hours when of necessity artificial light must be employed.

I think great credit is due to the *Illuminating Engineer* for the way in which it has adapted itself to the requirements of the present time, and I sincerely hope that the experience of the past ten years will form a preliminary to an equally successful future.

**Mr. G. Campbell** (*Managing Director, The Benjamin Electric Ltd.*) :—

As a member of the Illuminating Engineering Society since 1910 it is gratifying to learn that its official organ has now reached its tenth anniversary, and I would take this opportunity of wishing it every success in the future.

To those who, like myself, are associated with the manufacture of Reflectors and Lighting Appliances, the far-reaching importance of the Illuminating Engineering movement is manifest. We have noted a steady advance in the critical appreciation on the part of those interested in matters of illumination and the distinction between a scientifically designed lighting unit and a crudely constructed or inefficient one is much more generally understood and appreciated than formerly. We have found in connection with the lighting of the large munition factories throughout the kingdom, with which we have had a great deal to do, that the question of the best method of lighting has been generally considered from an intelligent standpoint with the result that it can be claimed that the standard of lighting has greatly improved.

We feel sure that a still wider dissemination of knowledge on lighting matters would be of national value and the broad aspect of the Illuminating Engineering movement is highly commendable.

* "The Province of the Illuminating Engineer, by Leon Gaster (*Proceedings of the Association of Engineers-in-Charge*, Vol. xiii, No. 2, Session 1907-1908).

**Mr. S. E. Doane** (*Chief Engineer, National Lamp Works of the General Electric Co.*, CLEVELAND, *U.S.A.*):—

It has been most interesting to me to notice in this wartime that you in England and we in America have achieved the common-sense corrections of our habits and practices which the energetic and public-spirited and far-seeing would have achieved long since, but for the apathy and lack of interest of the public. This is all changed and the way this country stands for conscription, subjects itself to war taxes, raises money for Liberty Bonds, Red Cross, etc., is to my mind one of the most inspiring experiences of recent years.

It is intensely interesting to me, living as I do in a district which has also a very large population of German-born parentage, to notice that the point of view is no whit different among such who came to this country with deliberate intent of making it their home than among ourselves. Cleveland has led this nation in its patriotic response on all these questions. The few of foreign birth who have not responded have been more than compensated for by those who seem to have felt that they had an extra obligation because of their accident of birth.

This observation leads up to the thought that the close of this war will see a larger desire on the part of all peoples for best practice and a fuller realisation of what scientific achievement means. A much larger percentage of our population have experienced vivid living contact with scientific achievement and scientific men. I am looking forward to an international scientific renaissance in which illuminating engineering will play its part. From the larger experience which has fallen to the lot of the *Illuminating Engineer* in this country, I would counsel you to be particularly vigorous in urging the standardisation of essential dimensions in lamps, lamp caps, shadeholders, the necks of reflectors, light-centre dimensions on units of various sizes, etc., in order to furnish the artisan with the assistance which he has a right to expect from the manufacturer.

I cannot help feeling that the fact that the engineers in the United States are pioneers along these lines and have so thoroughly standardised these dimensions for so large a part of the world's total output should predispose the English engineers to adopt the same dimensions.

I am very sure that an international conference after the war will be most desirable. I can assure you that we will lend it every support, and while I feel that international standardisation may be somewhat delayed, international conferences will do more to bring it about than any one thing.

If fortune favours me I shall be in Europe soon after the war closes to learn those lessons which the war has taught. I believe that the sentiment of England and America will be decidedly in favour of a very close future co-operation on all points, and I would be very much pleased if anything I can do will tend to line up England, France and America.

Of course I hope that the close of the war will see even a broader co-operation than this so that, instead of again having the world divided into camps or spheres of influence, even those who are now our enemies will have a disposition to co-operation instead of antagonism.

Permit me to offer you congratulations on your ten years of splendid existence and to extend to you my best wishes for a long life and prosperity.

**Mr. J. W. Elliott** (*Edison Swan Electric Co., Ltd.*):—

Light, as we know, is as old as the world, but artificial light, or illuminants, are the results of the men of inventive genius who have laboured all through the years to invent or improve the artificial means of lighting.

There have been wonderful developments and a succession of rapid changes in electric lighting ever since the invention of the first incandescent electric lamp in this country by the late Sir Joseph Swan, a little more than a third of a century ago.

The Illuminating Engineering Society recognised his work by conferring on him honorary membership of the Society.

My company was associated with much of the early pioneering work, and naturally have taken a special interest in the growth and developments in lighting. As one having a long association with the company, and as a Member of the Illuminating Engineering Society, I have watched with keen interest the new developments and improvements in electric lamps and adjuncts which have been brought under the notice of the public, through the medium of the Society, where they have been freely discussed and criticised and subsequently reported in its official organ, the *Illuminating Engineer*.

Advances in illuminants have been accompanied by a steadily growing appreciation of the need of using them wisely, and in the work of spreading a knowledge of this equally important section of the lighting art, your Journal, and the Society, have taken a leading part.

At this epoch in the Society's existence, it is pleasant to reflect that this country, which was the home of so many early developments in electric lighting, was also the first in Europe to establish a Journal and a Society exclusively devoted to the study of illumination.

I wish you a prosperous future and still further fields of usefulness.

**Mr. J. Y. Fletcher** (*Director of the General Electric Co., Ltd.*):—

Hearty congratulations to the *Illuminating Engineer* on attaining its tenth birthday.

Ten years ago the expression "Illuminating Engineering" conveyed nothing except to a select few—to-day it is a recognised branch of engineering, not only amongst manufacturers of lighting apparatus, but also to an ever-increasing body of light-users. For this change of attitude our thanks are due to the educational campaign conducted with such conspicuous ability and energy in the pages of the *Illuminating Engineer*, which has spread broadcast the principles underlying scientific illumination as brought out in the many able discussions which have taken place at the meetings of the Illuminating Engineering Society, of which the Journal is the official organ.

While appreciating to the fullest extent the successful pioneer work done by the Society and the Journal "running in tandem," I feel that yet greater work lies before them: firstly, as the training ground for our illuminating engineers of the future; secondly, as the centre of encouragement for new ideas and new ways of dealing with old problems; thirdly, as propagandist.

I conclude, therefore, by wishing the *Illuminating Engineer* many happy returns of the day.

**Mr. C. Hoddle** (*Managing Director of the Thorn and Hoddle Acetylene Co., Ltd.*):

I am very glad to learn that the *Illuminating Engineer* has just completed ten years of existence. The journal and the Illuminating Engineering Society have both done most useful work in providing an opportunity for the discussion of lighting problems by those connected with all illuminants.

Makers of acetylene generators, lamps, and appliances recognise the need for such discussion, and while we have our own special problems to solve, we also meet many questions which present themselves in all forms of lighting. During the war our work has extended in many new and special fields, and many of our activities must be curtailed for the moment. But there will always remain abundant opportunities for more scientific methods in the application of acetylene in lighting, welding, etc., and it is to be hoped that your Journal will continue for many years to come to develop its own unique field of work.

**Mr. J. Wyatt Ife** (*Secretary, Holophane Ltd.*):—

It is a source of gratification to me that I am able to congratulate you upon the *Illuminating Engineer* having now completed the tenth year of its existence.

As one of the original members of the Illuminating Engineering Society, the issues of your Journal have been continually beneath my notice from the first number, and a review of each number as it has appeared has served to show that its existence is fully justified, and that the prognostications, which one heard in several quarters, that it would be but a

matter of a short time before the whole subject of illumination was written to exhaustion, were quite erroneous.

During the lifetime of your journal, the progress in the way of handling schemes of illumination in a thorough and scientific manner has been most marked, and undoubtedly a great deal is owing to your propaganda and treatment of the subject.

One of the most pleasing aspects, to my mind, is the keener interest which is now taken by the consumer, and also by Municipal Authorities and Governmental Departments in lighting, and their desire to secure the maximum results combined with efficiency and economy in all illumination in their control.

The need of employing the skilful illuminating engineer to plan and supervise lighting installations of all kinds has become generally recognised, and I sincerely hope that the journal controlled by you will continue to flourish and expand, playing its part in the education of the public in the necessity and importance of good and efficient illumination.

**Mr. O. P. Macfarlane** (*Messrs. Blanchard Lamps (British), Ltd.*) :—

I observe with interest that the *Illuminating Engineer* has just completed ten years of useful work.

Its existence has been of great value in making known the aims and objects of the Illuminating Engineering Society in its capacity of official organ.

As one associated with the manufacture of incandescent oil lamps, I fully recognise the value of this impartial platform for the discussion of lighting problems, and, as a member of the Council of the Society, I have had many opportunities of judging how widely its influence has been applied in turn to educate different sections of the public in matters of illumination.

In common with other makers of lighting appliances, our efforts are at present necessarily largely devoted to the needs of the war. But we look forward in the future to the resumption of work through normal channels, and we shall then feel the benefit of the Society's work.

**Mr. H. Staniforth** (*Messrs. Jas. Milne and Sons, Ltd.*, EDINBURGH) :—

I note that you are putting out a special Decennial Number of the *Illuminating Engineer.*

War conditions have driven us completely out of the lighting business for the time being, but we have considerable preparations made for taking up the matter more strongly after the war.

I do not doubt that in the preparations being made for improving our trading and manufacturing systems after the war, lighting will play a great part and the Illuminating Engineering Society and its Journal, the *Illuminating Engineer*, will be looked to by manufacturers as the Home of Progress in Scientific Illumination. . . . I feel sure that both the strength of the Society and its sphere of action will be very greatly augmented during the period immediately following the declaration of peace.

I think that the lighting industry is indebted both to yourself and your staff for the energy and tenacity displayed during these very trying times. . . .

**Mr. S. E. Thornton** (*Chairman of Messrs. W. Sugg and Co., Ltd.*) :—

I can hardly realise that it is ten years since you founded the *Illuminating Engineer*, but I can appreciate the rapid developments in lighting by all illuminants during this period.

The firm with which I am associated was responsible for many of the earliest gas lighting installations in this city, and we have had every opportunity of watching the progress in illumination by gas and electricity from its earliest developments. You will also recollect that the late Mr. William Sugg was identified with much early pioneering work in photometry, and we have still specimens of the historic apparatus which he designed for this purpose, and for the improvement and comfort of gas lighting.

It therefore gives me great pleasure to congratulate the *Illuminating Engineer* on the completion of ten years of useful existence during which, in conjunction with the Illuminating Engineering Society, it has done much to advance the science and art of illumination.

As a member of the Council I have watched with great interest the many enterprising steps it has taken in connection with such matters as lighting of schools, factories, picture galleries, etc., to kindle public interest in lighting. This work has been of the utmost value to the lighting industry, and I hope that it will continue on prosperous and expanding lines for many years to come.

**Mr. C. F. Tilley** (*Director of the Tilley High-Pressure Gas Syndicate*) :—

It is with great pleasure that I notice the completion of ten years' work of the *Illuminating Engineer*, and as one associated with what I believe is the oldest firm of manufacturers of gas-lighting appliances in this country (which has just completed 100 years of existence), I am naturally interested in your work. As a member of the Illuminating Engineering Society I have had many opportunities of appreciating the need for a wider knowledge of the proper methods of using sources of light, whether gas, electric, or any other illuminant. Your journal, as the official organ of the Society, has done much to make the principles of good illumination better known. . . .

**Mr. A. J. Whyte** (*Messrs. James Keith and Blackman, Ltd.*) :—

We congratulate you on the fact that you are now ten years old.

Undoubtedly in this period you have done much to further the question of standardising illumination, and, but for the war, doubtless legislation would have already resulted, following on the efforts you made, and which culminated in the appointment of a Home Office Committee to make up a report on the matter. In this connection we were glad to have the opportunity to put forward our views as representing the high pressure gas side of the question.

We would express the hope that some tangible results will follow after the war, to the efforts that you and others have made to draw attention to the importance of lighting, particularly workshop and factory lighting.

**Mr. F. W. Wilcox** (*General Manager, Lamp and Wiring Dept., British Thomson-Houston Co., Ltd., London*) :—

I gladly take this occasion of congratulating the *Illuminating Engineer* on the termination of ten years of useful work in the cause of better illumination.

Some of the makers of lamps and lighting appliances are well aware of the need for public education in these matters, and recognise that this can be greatly aided through the medium of a Society and a Journal representative of all forms of lighting, with no axe to grind and thus able to consider both the needs of the lighting industry and the requirements of the general public.

In particular, it has done useful service in emphasising the lessons conveyed in the Home Office Report on Lighting in Factories and Workshops. In our own illuminating engineering work we observe a growing demand for guidance in the choice of lamps and fittings, and for information on the best method of applying them to practical problems. The need for proper lighting in factories is recognised by the Ministry of Munitions and large numbers of important industrial establishments continues to be more fully appreciated every year. This attitude is in a large measure due to the influence of your Journal and the Illuminating Engineering Society.

As manufacturers of electric lamps and lighting appliances, reflectors and fittings, we are anxious to supply the products best adapted to the more discriminating demand thus created, and to supply information as to how they should be used.

In facilitating the exchange of views on this subject, the platform of the Illuminating Engineering Society has also been of considerable value, and, in common with the *Illuminating Engineer*, has discharged its dual function of promoting discussion on technical subjects, assisting to establish comprehensive and exact standards and results, and then conveying the results to the general public. Their influence in both directions has been much appreciated by the lighting industry, and I hope that in future their present co-operation with manufacturers will be extended and developed.

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# 2

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

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(Founded in London, 1909.)

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# EDITORIAL.

## Economy in Lighting and Fuel Saving.

The question of economy in lighting with a view to fuel saving was dealt with by the Illuminating Engineering Society in London in May last year, and was recently the subject of discussion at a joint meeting of the American Illuminating Engineering Society, the American Gas Institute, and the American Institute of Electrical Engineers on February 14th, when a paper on " Lighting Curtailments " was read by Mr. P. S. Millar.

Attention has again been drawn to the matter by a circular issued by Mr. Guy Calthorp, the Controller of Coal Mines, requesting users of gas and electricity to economise in the use of these commodities. While we entirely agree that at a time like the present every effort should be made to avoid waste of light, it should nevertheless be understood that the consumption of coal for lighting purposes by gas and electrical supply companies is only a very small proportion, estimated at about 2½ per cent. of the total output of the country. Any economy that can be made in this direction, therefore, would have a relatively small effect on the general

problem. Of much greater importance are the savings in transport possible by proper selection and treatment of coal, a matter which has been the subject of much comment in the gas journals. It is stated that much of the so-called coal now being sent from the pits contains 10, 20, or even 30 per cent. of non-combustible rubbish, and that the carriage of this refuse to the supply works is mere waste. This is surely a point that is well worth looking into before the relatively minute saving possible from lighting economies is pressed to undue lengths.

The desirability of economy in lighting is of more importance in relation to the local difficulties of supply companies, working with insufficient plant, and endeavouring to cope with a greatly increased industrial demand. Improvement in these circumstances, however, can only be attained by securing the co-operation of those with expert and local knowledge. In some cases, *e.g.*, in districts largely residential, domestic economies would relieve the situation; in others, where the lighting enjoyed by theatres, restaurants, and shops is a considerable item, restrictions during certain hours, or on certain days, may be helpful; but in districts where the load is almost exclusively industrial, other measures must be contrived; closer co-operation between consumer and supply company must be secured and the load so adjusted as not to throw the maximum demand on to an inconvenient time of the day.

Besides this, there are other factors which must be considered, and which may render desirable certain steps, even though the reduction in lighting secured would lead only to a relatively insignificant saving in fuel. For example, there are the saving in transport of coal and the relief of railway traffic occasioned by the earlier closing of places of entertainment, and the desirability of encouraging the dispersal of people to their homes, rather than the assembling of crowds at theatres, etc., after dark, when air raids are possible. These points will no doubt be considered by the Authorities in framing any future Regulations.

In any case measures of economy should follow a systematic and considered plan. Economies should affect, *first*, lighting for entertainment purposes, theatres, cinema halls, restaurants, etc.; next, lighting that is a matter of public convenience, *e.g.*, in shop-windows, public buildings, residences, and on railways, etc., and is used for non-essential industries; while the third class of lighting, requisite for essential industries, should enjoy immunity except in the last resort. A systematic survey of the lighting throughout the country would be a necessary preliminary to such a classification under the above headings.

The matter is, however, complicated by the variety of departments with powers to deal with lighting. Correlation of the functions of these various Departments is clearly necessary. They should avail themselves of expert advice and local knowledge, especially in approaching consumers. In order to be effectual appeals to economise should be supplemented by clear and precise instructions as to the form the economies should take. The Illuminating Engineering Society, which has already expressed its willingness to co-operate, could doubtless yield material assistance, both in preparing statistical data on which to take action, and in drafting communications to various sections of the community. The essential thing is to eliminate waste of light. One should therefore encourage (1) the removal of all unnecessary lamps, (2) the turning off of lamps at times when no longer required, (3) the replacing, so far as possible, of old and inefficient lamps by modern and more efficient types, and (4) the use of proper reflectors.

**Savings through Proper Maintenance of Lamps and Lighting Appliances.**

Among the measures for economy in lighting great stress should be laid on the proper maintenance and cleaning of lamps and lighting appliances. If lamps and the globes and reflectors used with them are allowed to become encrusted with dirt and dust the illumination may eventually be diminished by 20, 30 or even 50 per cent. according to the nature of the factory. This leads to the obvious inference that, if the lamps and reflectors were kept clean, lamps of smaller consumption could be used to provide the existing illumination. Similarly the continued use of old-fashioned forms of lamps, which have been in use far too long and have accordingly deteriorated, is false economy; for the substitution of newer and more efficient units would help to bring about a needed saving in gas or electricity, and the cost involved would soon be repaid out of the saving made.

Lamps and lighting appliances, both gas and electric, should be cleaned at regular intervals in the same way as the windows providing access for natural illumination, and maintenance methods should be encouraged in every possible way. While as yet maintenance of artificial lighting has rarely been attempted by electric supply companies in this country (though maintenance of industrial motors is general), it has received much attention from gas companies both here and in America. We have before us a report (Bull. No. 99) of some tests carried out by the Bureau of Standards (Washington) into the conditions in ten of the larger cities in the United States.

The most potent factors in causing breakdown appear to be draughts and dust, responsible respectively for 14—15 and 16 per cent. of the units inspected; and vibration and shock were responsible for 10 per cent. and 5 per cent. of units respectively. The alinement and quality of mantles are also of consequence. In general the mantles of units under company maintenance were of good quality, while about 50 per cent. of those which were not under the company's supervision were of poor class.

This is an important result for it shows that, apart from liability to failure the illumination provided in these cases would presumably be habitually lower than in the case of consumers who receive mantles of good quality from the local company. This is one valuable service which gas companies can render to consumers. But the investigation also shows clearly the value of maintenance in preventing minor disorders, due to the causes mentioned above. It was found that lamps not on regular maintenance were likely to be defective *five and a half times* as frequently as those which were regularly maintained; moreover in the case of lamps under the company's supervision defects were only noted on one lamp in three, whereas on the average the defects in lamps not so maintained exceeded one per lamp. Plainly stated this means that when consumers do not avail themselves of the company's maintenance scheme their lamps are practically never giving their full output. Naturally many of the defects would be slight and possibly unnoticed by the consumer, but their cumulative effect on the service would be considerable.

Advice on such matters could often be given by trained and educated women; some companies, for example, the Gas Light and Coke Co. and the South Metropolitan Gas Co., have already been making effective use of their services in this direction. At the present time women-canvassers could help in bringing about a needed economy in the use of gas and electricity, and after the war advice to consumers on lighting, heating and cooking will still remain a useful field for women's work.

## A Code for School Lighting.

In this issue we reproduce (pp. 47—52) the Code on School Lighting prepared by a Committee of the Illuminating Engineering Society in the United States which deserves careful study. Readers will recall that the artificial lighting of schools was dealt with by a joint committee of the Illuminating Engineering Society in this country in 1913, while a further report of natural lighting was issued in the following year. Some supplementary investigations were suggested in these Reports, but were inevitably postponed owing to the outbreak of war. They will however be resumed at the first opportunity and meantime it is useful to have this series of recommendations from the United States which agree closely with the suggestions made in this country.

We observe that the same general conclusions are emphasised: the avoidance of glare either from imperfectly shaded lamps or from unduly bright reflecting surfaces, the prevention of excessive contrasts and the provision of sufficient illumination. The minimum illumination on desks in schoolrooms is given as 3 foot-candles, and other appropriate values are assigned to passages, assembly rooms, workshops, etc. In common with the Committee in this country the authors of the Code suggest that walls should have a moderate reflecting power, such as that furnished by light grey, light buff or olive green surfaces, and that ceilings and friezes should be white or cream in tint. Walls, desk tops and other woodwork should have a dull finish. As a guide to the general lighting conditions in schoolrooms it is recommended that the contrast between adjacent bright surfaces should not exceed 20 : 1, a recommendation which, if strictly carried out, would give very restful conditions of illumination. The Committee refer to the growing popularity of indirect and semi-indirect methods of lighting. Local lighting is in general unsatisfactory except in the case of lamps placed quite close to special objects such as blackboards, maps, charts, etc. Except in very rare instances bare light sources should not be exposed to view.

The rather difficult problem of blackboard lighting is dealt with in some detail. A great deal can be done towards the solution of this problem by the proper location of lamps and the design of fittings to give the right distribution of light, but the nature of the blackboard surface is obviously a most important factor. It would be a great help if some form of surface which would not become shiny with use, could be easily cleaned and would not gradually lose its original dead black character could be introduced.

The Code also contains a considerable amount of useful supplementary information on the planning of lighting for schoolrooms, and the factors controlling admission of daylight. A table of "coefficients of utilisation" (*i.e.*, the percentage of the total light-flux reaching the working plane) is furnished, the effect of direct, indirect, and semi-indirect lighting, and the influence of the nature of the ceilings and walls, being roughly indicated. Such data should be very useful to those concerned with schoolroom lighting. The Code is a useful piece of work, the more satisfactory as it shows how closely in agreement are the ideas of experts in this country and in the United States. In these days when educational problems are so much to the fore, the provision of adequate illumination in schools and colleges is as much a part of the duty of educational authorities as the actual instruction given, and it will be our task to ensure that this aspect of education receives proper recognition.

LEON GASTER.

# A CODE ON THE LIGHTING OF SCHOOL BUILDINGS.

(Abstract of a Code issued by the Illuminating Engineering Society in the United States; Original Draft prepared by the Committee on School Lighting, consisting of N. M. Black, R. B. Ely, L. O. Grondahl, J. D. Lee, F. Park Lewis, H. H. Magdsick, F. K. Richtmyer, and M. Luckiesh (Chairman); revised and codified by the Committee on Lighting Legislation, consisting of O. H. Basquin, C. O. Bond, C. E. Clewell, C. W. Cutler, A. B. Lathrop, C. L. Law, M. Luckiesh, F. J. Miller, C. B. Myers, T. Scofiled, G. H. Stickney, L. A. Tanzer, F. A. Vaughn, A. H. Young, and L. B. Marks (Chairman).

## INTRODUCTION.

IN the preface to the Code it is mentioned that there are 20,000,000 school children in the United States, who are devoting several hours daily to study or to other work equally trying to the eyes. According to available statistics nearly 10 per cent. of children examined are found to have defective vision.

The severe requirements imposed on children's eyes by modern educational methods make it essential to secure the best working conditions, among which lighting is of first importance. Improper lighting causes eye-strain, resulting in functional disorders, near-sightedness and other defects of the eyes.

The following Code of Lighting for School Buildings has been prepared in order to provide authoritative information for legislative bodies, school boards, and others who are interested in enactments, rules, and regulations for better lighting, and should also be useful to school authorities.

The following is a summary of the chief recommendations made:—

**Article I. General Requirements.**—When in use, all buildings should be provided, during those hours when daylight is inadequate, with artificial light according to the following Articles.

Buildings hereafter constructed should be so designed that the daylight in the working space is reasonably uniform and the darkest part of any work space is adequately illuminated under normal exterior daylight conditions.*

* Daylight illumination values should be at least twice the values given in the Table, Article II., for artificial lighting.

**Article II. Intensity of Artificial Illumination.**—The desirable illumination to be provided and the minimum to be maintained are given in the following table,* being based upon present ideas of good practice.

DESIRABLE AND MINIMUM ILLUMINATION.

| | Artificial lighting Foot-candles (Lumens per square foot)† At the work | |
|---|---|---|
| | Minimum | Ordinary practice ‡ |
| Storage spaces .. .. | 0·25 | 0·5– 1·0 |
| Stairways, corridors .. | 0·5 | 1·0– 2·5 |
| Gymnasiums .. .. | 1·0 | 2·0– 5·0 |
| Rough shop work .. | 1·25 | 2·0– 4·0 |
| Auditoriums, assembly rooms .. .. .. | 1·5 | 2·5– 4·0 |
| Class rooms, study rooms, libraries, laboratories, blackboards .. .. | 3·0 | 3·5– 6·0 |
| Fine shop work .. | 3·5 | 4·0– 8·0 |
| Sewing, drafting rooms | 5·0 | 6·0–12·0 |

**Article III. Shading of Lamps.**—Lamps should be suitably shaded to minimise glare. Glare, either from lamps or from

*The illumination intensity should be measured on the important plane which may be the desk-top, blackboard, etc.

The method of computing the flux of light (lumens) required to do any desired illumination is described under the heading "Design of Lighting Installation" on page 50.

For more specific information regarding the lighting of shops, see "*Code of Lighting: Factories, Mills and Other Work Places*," issued by the Illuminating Engineering Society (U.S.A.).

† It should be borne in mind that intensity of illumination is only one of the factors on which good seeing depends.

‡ Under the column headed "Ordinary practice," the upper portion of the range of intensities is preferable to the lower; where economy does not prohibit, even higher intensities than those cited are often desirable.

unduly bright reflecting surfaces, produces eye-strain.

**Article IV. Distribution of Light on the Work.**—Lamps should be so arranged as to secure a good distribution of light on the work, avoiding objectionable shadows and sharp contrasts of intensities.

**Article V. Colour and Finish of Interior.**—Walls should have a moderate reflection factor; the preferred colours are light grey, light buff, dark cream and light olive green. Ceilings and friezes should have a high reflection factor; the preferred colours are white and light cream. Walls, desk-tops and other woodwork should have a dull finish.

**Article VI. Switching and Controlling Apparatus.**—Basements, stairways, store rooms, and other parts of the building where required, should have switches or controlling apparatus at point of entrance.

**Article VII. Emergency Lighting.**—Emergency lighting should be provided at main stairways and exits to insure reliable operation when, through accident or other cause, the regular lighting is extinguished.

**Article VIII. Inspection and Maintenance.**—All parts of the lighting system should be properly maintained to prevent deterioration due to dirt-accumulation, burned-out lamps and other causes. To insure proper maintenance, frequent inspection should be made at regular intervals.

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## NOTES—Data and Recommendations.

### DAYLIGHT.

**Intensity of Daylight.**—In general, the minimum intensities of daylight illumination should be considerably greater than those provided in artificial lighting, owing to the adaptation of the eye to a much higher level of illumination (brightness) in the daytime.

**Direction of Light.**—One of the fundamental rules for proper lighting is to have the preponderance of light come from the left side. For this reason many school authorities advocate *unilateral* lighting, that is, lighting by windows located on one side of the room only, especially for class rooms. This method of lighting is recommended where the class rooms do not exceed about 20 ft. (6·1 m.) in width, with windows about 10 ft. (3 m.) high. If the rooms are much wider than this, *bilateral* lighting, that is, lighting by windows located on two sides of the room, may be required in order to provide sufficient illumination in every part of the room and at the same time to prevent too great a diversity of contrast in the intensity of light on the working spaces.

Windows at the left and rear where practicable are preferable to those on the left and right sides of the room, because of cross shadows created by the latter arrangement. Lighting by overhead sources of natural illumination has ordinarily little application in class rooms and has found little favour in practice.

The sky as seen through a window is a source of glare. For this reason the seating arrangements should always be such that the occupants (pupils) of the room do not face the windows.

**Window Openings.**—Tests of daylight in well-lighted school buildings indicate that in general, the window area should not fall below 20 per cent. of the floor area when windows are located on two sides of the room, and not below 25 per cent. of the floor area when windows are on one side only.

As the upper part of the window is more effective in lighting the interior than the lower part, it is recommended that the windows extend as close to the ceiling as practicable.

**Lighting Value of a Window.**—The lighting value of a window at any given location in the room will depend upon the brightness of the sky, the amount of sky visible through the window at the given location in the room, and indirectly upon the reflection factor of the surroundings and the dimensions of the room.

To secure the highest lighting value it is recommended that the room be so designed that no part is more distant from a window than twice the height of the top of the window from the floor.

Observations in well-lighted school rooms having a comparatively unob-

structed horizon, show that under normal conditions of daylight, satisfactory illumination is usually obtained when the visible sky subtends a minimum vertical angle of 5° at any working point of the room.

In cases in which the horizon is obstructed, as by adjacent high buildings or by high trees, provision should be made for a larger window area than would otherwise be required; also if need be, for redirecting the light into the room by means of prismatic glass in the upper sashes of the windows, or by prismed canopies outside of the windows.

**Window Shades.**—Although direct sunlight is desirable in interiors from a hygienic standpoint, it is often necessary to exclude or diffuse it by means of shades. These shades should perform several functions, namely, the diffusion of direct sunlight, the control of illumination to secure reasonable uniformity, the elimination of glare from the visible sky and the elimination of glare from the blackboards wherever possible. These requirements make it desirable to equip each window, especially in class rooms, with two shades operated by double rollers placed near the level of the meeting rail. The window shades may thus be raised or lowered from the middle, which provides the maximum elasticity for shading and diffusing the light. The shades should be preferably of yellow-coloured material that is sufficiently translucent to transmit a considerable percentage of the light, while at the same time diffusing it.

A more complete control of the light may be obtained by the use of two independent sets of shades at each window. Where two sets of shades are used, one should be preferably a very dark green of heavy material that will exclude the light entirely, and the other preferably a yellow-coloured material as above described.

**Light Courts.**—Reflection of light from the walls of courts is very helpful in increasing interior illumination. Hence the walls of courts should have high reflection factors. Dark colours should be avoided.

**Maintenance.**—Windows and overhead sources of natural light (so-called skylights) should be washed at frequent intervals and surfaces such as ceilings and walls should be cleaned and refinished sufficiently often to insure their efficiency as reflecting surfaces. It should be borne in mind that the maintenance of adequate daylight indoors is also dependent upon various external factors, such as the future erection of buildings and the growth of trees or vines.

## ARTIFICIAL LIGHT.

**Systems of Lighting.**—It is customary to divide the systems of artificial lighting into three classes, namely, *direct, semi-indirect* and *indirect*. This division is arbitrary and the boundary lines are quite indefinite.

A direct lighting system is known as one in which most of the light reaches the working plane directly from the lighting unit including the accessory which may be an opaque or glass reflector or a totally enclosing transparent or translucent envelope. Direct lighting systems may be further classified as *localised* and *general* or distributing. In the former the units are so placed as to light local working points, and in the latter they are well distributed so as to light the whole area more or less uniformly.

A semi-indirect system is known as one in which a portion of the light reaches the working plane directly from the unit and a relatively large portion reaches the working plane indirectly, by reflection from the ceiling and walls. The accessory is usually an inverted diffusing bowl or glass reflector. When this glass has a high transmission factor the lighting effect approaches that of ordinary direct lighting, and when of low transmission, the effect approaches that of indirect lighting.

An indirect system is known as one in which all or practically all the light reaches the working point indirectly after reflection from the ceiling and walls. The accessory is usually an opaque or slightly translucent inverted bowl or shade containing a reflecting medium.

All three of these systems of lighting are in successful use in schools. There has been a growing preference for semi-indirect and indirect lighting, especially since the introduction of modern lamps

of great brilliancy. Local lighting by lamps placed close to the work is unsatisfactory except for special cases such as the lighting of blackboards, maps, charts, etc.

**Shading of Lamps.**—Except in very rare instances bare light sources should not be exposed to view. They should always be adequately shaded or completely hidden. Even when shaded by translucent media, such as dense glassware, the lighting units should be placed well out of the ordinary range of vision; in other words it is recommended that lighting units be of low brightness,* even if they are located high in the field of view.

The maximum brightness contrast of juxtaposed surfaces in the normal visual field should be preferably not greater than 20 to 1; that is to say, the darkest part of the working space observed should have a brightness preferably not less than one-twentieth of that of the brightest part.

**Glossy Surfaces and Eye-Strain.**—Glossy surfaces of paper, woodwork, desk-tops, walls and blackboards are likely to cause eye-strain because of specular or mirror-like reflection of images of light sources, especially when artificial light is used. Mat or dull finished surfaces are recommended. It is to be noted that a high reflection factor does not necessarily imply a polished or glazed surface.

To minimise eye-strain it is recommended that unglazed paper and large plain type be used in school books.

Children should be taught to hold their books properly, to assume a correct position relative to the light source, and to safeguard their vision.

**Design of Lighting Installation.**—The illumination intensity on the horizontal working plane should be as uniform as possible. The variation should not be greater than 4 to 1.*

* Preferably not to exceed 250 millilamberts. A millilambert is equal to the brightness of a perfectly reflecting and diffusing surface illuminated to an intensity of 0·929 foot-candle (0·929 lumen per square foot).

The following table shows the order of magnitude of the brightness of some light sources in common use:—

| | Brightness (approximate millilamberts). |
|---|---|
| Indirect lighting: ceiling, directly above the lighting unit .. .. .. | 5 to 75. |
| Semi-indirect lighting:—heavy density glassware | 35 to 100. |
| Semi-indirect lighting: light density glassware | 200 to 1,000. |
| Direct lighting: 10 in. (25 cm.) opal glass ball containing 100-watt vacuum tungsten lamp at centre | 500. |
| Direct lighting: vacuum tungsten lamp (frosted), in open bottom reflector | 2,000 to 3,000. |
| Vacuum tungsten lamp, filament exposed to view | 500,000. |
| Gas-filled tungsten lamp, filament exposed to view | 2,000,000. |
| Gas-mantle, bare .. .. | 15,000. |
| Gas-mantle, concealed in 6 in. (15 cm.) opal glass globe .. .. .. | 1,000. |
| Mercury arc tube (glass) .. | 8,000. |
| Daylight: clear blue sky | 1,000. |

Approximate Coefficients of Utilisation—Modern Lighting Equipment.

| | Light colour walls. Light colour ceiling. | Medium colour walls. Light colour ceiling. |
|---|---|---|
| *Small Rooms* (Offices, Corridors, etc.). | | |
| Direct lighting; dense glass (open bottom reflectors) | 0·40 | 0·35 |
| Semi-indirect lighting; dense glass .. .. .. | 0·25 | 0·22 |
| Indirect lighting .. .. | 0·23 | 0·20 |
| *Medium Sized Rooms* (Class Rooms, Laboratories, etc.). | | |
| Direct lighting; dense glass (open bottom reflectors) .. | 0·50 | 0·45 |
| Semi-indirect lighting; dense glass .. .. .. | 0·35 | 0·30 |
| Indirect lighting .. .. | 0·30 | 0·25 |
| *Large Rooms* (Auditoriums, etc.). | | |
| Direct lighting; dense glass (open bottom reflectors) .. | 0·60 | 0·60 |
| Semi-indirect lighting; dense glass .. .. .. | 0·45 | 0·40 |
| Indirect lighting 7 .. .. | 0·40 | 0·38 |

The chief factors which must be considered in arriving at the size and number of lamps to be used in a given room are (1) the floor area; (2) the total luminous

* This ratio refers to the light received by the object illuminated and should not be confused with the ratio of 20 to 1 for brightness contrast previously given on page 10, which refers to the light radiated by the object. For example, a blackboard and a white sheet of paper on it may receive the same amount of light, but the latter will reflect much more light than the former, thus causing a marked brightness contrast between the two surfaces.

flux* emitted per lamp, and (3) *coefficient of utilisation* of the particular system considered. The first should be measured in square feet. The second may be obtained from a data book supplied by the manufacturers of lamps. The third involves many factors such as the relative dimensions of the room, the reflection factor of the surroundings, the number of lighting units and their mounting height, and the system of lighting. By *coefficient of utilisation* is meant the proportion of the total light flux emitted by the lamps which is effective on the working plane. In the accompanying table approximate coefficients of utilisation for modern lighting equipment are given. The working plane in this case is a horizontal plane 30 in. (76 cm.) above the floor. These values refer to the initial installation without any allowance for depreciation.

For determining approximately the size and number of lamps to be used in a given room by means of the coefficients of utilisation given in the preceding table, it is necessary to know the luminous output in lumens per watt for the electric lamps considered or in lumens per cubic foot of gas consumed per hour if gas lamps are considered. At the present time (1917) the light output of tungsten filament electric incandescent lamps, based on average service conditions of regularly maintained installations, ranges from 8 lumens per watt for the smaller vacuum tungsten lamps to 14 lumens per watt for the larger gas-filled tungsten lamps employed in school lighting. For incandescent gas systems similar service values range from 150 to 250 lumens per cubic foot of artificial gas consumed per hour. The computation for the total lumens required to give a certain illumination intensity in foot-candles is as follows :

N=number of lamps.

L=lumens output per lamp.

E=coefficient of utilisation.

A=area of floor or horizontal working plane in square feet.

I=illumination intensity in foot-candles.

$$\frac{N \times L \times E}{A} = I$$

that is, the number of lamps multiplied by the output per lamp in lumens, multiplied by the coefficient of utilisation, divided by the area of the horizontal working plane in square feet, gives the illumination intensity in foot-candles.

If the size of the lamps is to be ascertained the computation is made thus :

$$L = \frac{I \times A}{N \times E}$$

To illustrate by an example, assume a room, whose floor (also working plane) is 30 ft. by 18 ft. (9·1 by 5·5 m.), to be lighted by a semi-indirect system from six fixtures containing one lamp each. It will also be assumed that the ceiling is highly reflecting, the walls moderately reflecting, and the illumination intensity desired is 5 foot-candles. The luminous output required of each of the six lamps will be found by substituting the assumed values in the equation, thus :—

$$L = \frac{5 \times 30 \times 18}{60 \times 0{\cdot}30} = 1{,}500 \text{ lumens.}$$

Allowing a depreciation factor of 20 per cent., as representing a well maintained installation, the lumens actually required would be $\frac{1{,}500}{0{\cdot}8}$ =1,875 lumens. If gas-filled tungsten lamps are considered, whose average output under service conditions is 12 lumens per watt, it is seen that a 150-watt lamp in each fixture will give the desired results.

If gas mantle lamps are considered, whose average output in lumens under service conditions is 250 lumens per cubic foot of gas consumed per hour, it is seen that a lamp consuming 5 cubic feet of artificial gas per hour will be satisfactory in each fixture.

The above example is intended solely to illustrate the method of computation. Estimates of the illumination intensity obtained from an actual installation may also be made by a similar computation.

With the usual lighting equipments the distance between the units should not exceed one and one-half times the height of the apparent source of illumination above the working level.

* The flux is measured in lumens. A lumen is the unit of light flux and is the quantity of light required to illuminate 1 square foot of area to an average intensity of 1 foot-candle.

**Blackboards.**—Blackboards should be of minimum size practicable and should not be placed between windows. Their position should be carefully determined so as to eliminate the glare due to specular reflection of images of either artificial or natural light sources directly into the eyes of occupants of the room. The surface of blackboards should be as dull as possible and this dullness should be maintained.

Glare, due to specular reflection from blackboards, may be reduced or eliminated by lighting them by means of properly placed and well shaded local artificial sources.

In order to avoid excessive brightness contrast which is trying to the eyes, blackboards should not be placed on a white or highly reflecting wall.

**Maintenance.**—A systematic maintenance should be provided in order to insure against depreciation in the illumination intensity due to burned-out lamps, broken gas mantles, discoloration, etc., and to accumulations of dirt upon the lamps, and upon the surfaces of the reflecting and transmitting media. It is found in practice that carelessness in this respect may easily reduce the effective illumination by 50 per cent., especially in indirect and semi-indirect lighting.

(N.B.—In the original Code, copies of which can be obtained from THE ILLUMINATING ENGINEERING SOCIETY, 29, West 39th Street, NEW YORK, U.S.A., illustrations of typical good and bad installations are also included.

Readers interested in this subject may also be referred to the two Interim Reports dealing respectively with the Artificial and Natural Lighting of Schools issued by the Committee on School Lighting of the **Illuminating Engineering Society** (Founded in London, 1909), published in the *Illuminating Engineer* for July, 1913 (p. 364, Artificial Lighting), and July, 1914 (Natural Lighting) ).

## INDUSTRIAL RECONSTRUCTION.

THE Industrial Reconstruction Council held its inaugural meeting at the Guildhall on February 15th, when there was a large and representative attendance. After a welcome to the visitors had been given by the Lord Mayor, the chair was taken by Lord Burnham. Mr. E. J. P. Benn, Chairman of the Industrial Council, then gave an address summarising the aims which it had in view.

Mr. Benn remarked that the Whitley Report marked a big step towards the union of workers and employers in each trade for its general benefit. They desired to see established industrial self-government—trade parliaments at which all matters concerning any trade, such as hours of work and wages, education, industrial research, and the study of markets, etc., could be jointly discussed. Every employer and every man engaged in an industry should be a member of his trade council. The proper discussion of such subjects was beyond the scope of any individual and could only be dealt with by such co-operative action. Thus they would get nearer the ideal when industry would be recognised as one of the highest forms of national service and help to lay the foundations of peace and prosperity.

The Rt. Hon. Christopher Addison (Minister of Reconstruction) referred to the vast problems which would arise when the men released from the Army returned to civil life. The future demanded much greater productive capacity, and this could only be attained by industrial peace.

Mr. G. H. Roberts and Mr. J. H. Whitley, M.P., also pointed out the vital necessity for harmonious co-operation in the industrial world after the war, the latter remarking that he had received many applications for copies of the Whitley Report from officers and men in the trenches.

A motion approving the aims of the Industrial Reconstruction Council was proposed by Sir Wilfred Stokes, seconded by Sir Herbert Nield, M.P., and carried unanimously.

# THE COST OF ARTIFICIAL LIGHTING IN RELATION TO WAGES AND PRODUCTION.*

BY C. E. CLEWELL.

IN a recent article in *Industrial Management* Mr. C. E. Clewell takes up the much-discussed question of the relation of lighting costs to wages and production.

A system which would enable a manufacturer to appreciate at once the advantages of good illumination, on a purely cash basis, would be most useful in reinforcing the argument that good illumination pays for itself by preventing accidents, benefiting health, and improving production. These facts are generally appreciated, but numerical data are needed to force them home.

The problem of showing the actual gain in production, either in more work or better work, through improved lighting is not easy, owing to the difficulty of getting definite data from manufacturers. On the other hand, it is not difficult to present general arguments based on the money-value of time lost through defective lighting.

This is usually accomplished by ascertaining the number of minutes per day which for the corresponding wages are equal to the lighting costs for the day. It follows, therefore, that if the given number of minutes are more than saved by the presence of good light, whereas they would be lost under inadequate light, the good light may be classed as a paying investment.

As a matter of fact, there is an additional reason for comparing the lighting costs and wages in this manner. In any plant where a good system of lighting is contemplated, as a substitute for an old and inadequate system, the first cost of the new equipment often stands in the way of prompt action on the part of the management. By showing that the probable time which can be saved due to the new and improved equipment will more than pay for the new system the appeal to make the necessary outlay for new lamps and wiring is usually strong enough to bring about their adoption without further delay.

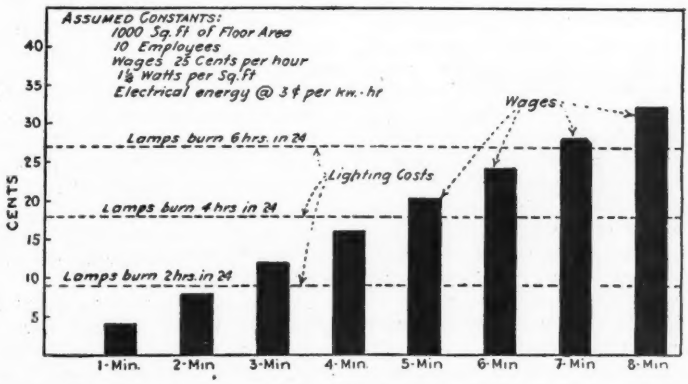


FIG. 1.—The solid spaces represent the wages for intervals of 1, 2, 3, etc., minutes. The ordinates of the horizontal dash lines represent the cost per day for lighting the area of 1,000 sq. ft. 2, 4 and 6 hours respectively. Note, for example, that when the lamps are burned two hours per day, the cost of the light is paid for if between two and three minutes are saved by each workman per day due primarily to the lighting facilities.

* Abstract of an article in *Industrial Management*.

Figure 1 shows graphically the total wage charges per 1,000 square feet of floor area in which 10 employees are stationed at a rate of 25 cents per hour. The solid areas indicate the wages for the 10 men for periods of one, two, three, up to eight minutes. The horizontal dash lines show the costs for light under different assumed numbers of hours' service per day, and at a given assumed rate per kilowatt-hour for electrical energy. This diagram indicates that under the given conditions, the lighting cost for two hours per day service is equivalent to the wages for between two and three minutes per day; for four hours per day service, between four and five minutes per day wages; for six hours per day service, between six and seven minutes per day wages.

Any section with conditions corresponding to those in Figure 1, which is experiencing a loss of six or seven minutes in the entire day due to poor light, can readily afford to install a modern system of lamps and burn them six hours per day. Four to six minutes out of an eight-hour day means roughly, one per cent. of the day. In poorly lighted sections, the actual losses of time, due to the inability to see properly, will usually reach values far in excess of these relatively small equivalents. Thus, the employees in a poorly lighted factory may not be able to start effective work on winter mornings for from one half to a full hour, or until the daylight conditions begin to reach satisfactory values for vision. Similar losses may easily occur toward the end of the day when the daylight begins to fall below satisfactory values in advance of the closing of the working day. Losses from these causes may readily be many times greater than the equivalent cost of light, thus making the argument for good light even stronger than a first glance at Figure 1 would indicate.

Mr. Clewell also traces the relation which ordinarily exists between annual lighting costs and annual wages in a typical factory section of given area.

We may assume a floor area of 3,000 square feet in which 25 employees are at work, with a wage-rate of 25 cents (approx. 1s.) per hour., the total annual wages for this area, including superintendence and overhead, may amount to 25,000 dollars (say £5,000). With an ordinary system of lighting with electric tungsten incandescent lamps the annual cost of lighting this area will be about 250 dollars (approx. £50), from which it appears that the lighting amounts to *only one per cent. of the wage item.*

A second device adopted by Mr. Clewell is to show how the admission of daylight into a building, by determining the number of hours during which artificial light must be employed, has also a considerable economic importance.

In Figure 2 the variations in the intensity of exterior illumination for average days in June, September and December are shown. These curves are based on tests in Great Britain. Taking these curves as a basis, let us assume that a given point within a factory has a constant daylight factor (ratio of interior to exterior illumination) of 0·6 per cent., and that a minimum value of the daylight intensity required for the work is three foot-candles. Under these conditions, it follows at once that the exterior illumination must have an intensity of at least 500 foot-candles to result in three foot-candles at the points within the building where the daylight factor is 0·6 per cent.

Hence a horizontal line drawn across each of these curves of Figure 2 at the point of 500 foot-candles, cuts the June curve at 6 a.m. and at 6 p.m.; the September curve at 7 a.m. and 5 p.m.; and the December curve at 10 a.m. and at 2 p.m. This brings about the rather startling conclusion that with the given daylight factor, the daylight conditions will be satisfactory from 6 a.m. to 6 p.m. on average June days; from 7 a.m. to 5 p.m. on average September days; and from 10 a.m. to 2 p.m. on average December days, with intermediate conditions for the intervening months.

It follows then that to maintain the prescribed value of three foot-candles at the work, artificial light will be required at least in the late afternoon of Autumn days, and through a large part of the mornings and afternoons of Winter days. The solid black portions of the three curves in Figure 2 indicate the parts of each day between 5 a.m. and 7 p.m. when artificial light will be necessary under such circumstances. On cloudy days when the

ordinates of the three curves in this diagram are much reduced below the values shown, the requirements for artificial light will be still greater. It is apparent, moreover, that artificial light will be required in a case like Figure 2, throughout the hours of the night when a night shift is employed, from 6 p.m. to 6 a.m. in June; from 5 p.m. to 7 a.m. in September; and from 2 p.m. to 10 a.m. in December.

parts of the floor space in such cases has the effect of definitely increasing the value of certain portions of the floor area.

Again, any factory which is properly equipped with windows for providing daylight conditions throughout, during all the hours of the working day, if unequipped with an artificial lighting system is not in a condition to utilise its floors for nightwork. Under the assumption that the plant in question is of sufficient

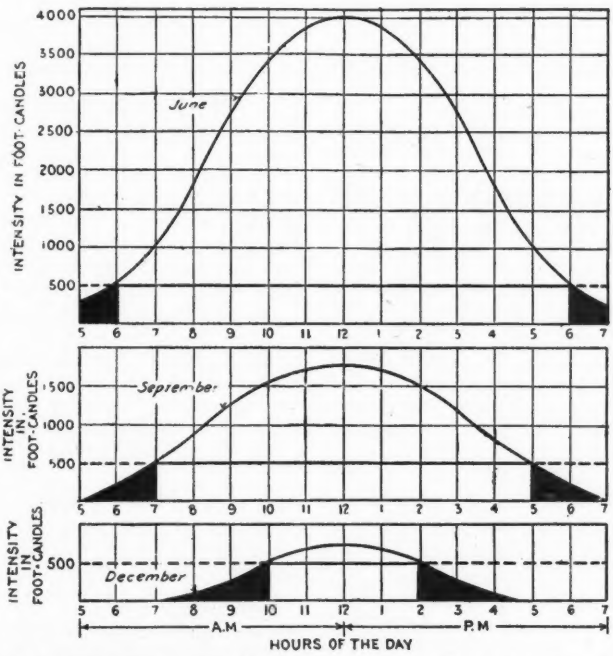


FIG. 2.—The lower curve shows that for a given prescribed minimum value of light for the work; for given exterior daylight conditions, and for a given "daylight factor" artificial light will be required before 10 a.m. and after 2 p.m. on an average December day. The shaded areas of each of the other two curves represent the periods between 5 a.m. and 7 p.m. when artificial light is required in a building with the given conditions if the prescribed minimum is to be maintained at all times.

In any factory building with a window equipment which furnishes sufficient daylight for the floor area relatively near the windows, but which does not properly light interior spaces more remote from the windows, the value of these interior spaces for manufacturing purposes is greatly reduced by the absence of suitable light. The addition of an artificial lighting system for properly lighting all

size to take care of all orders at the start, but a later increase in the volume of business makes it impossible to handle all of the work within the hours of a day-shift, two alternatives are faced.

Either the plant must be enlarged by new buildings or additions, which will require a constructional expense, or an artificial lighting system must be installed in the original plant for the purpose of

extending the working period to a 24-hour basis per day. In the first case, the extension of the plant is contemplated with a limitation of work to a day-shift only; in the second case, the fixed charges on the first cost and the operating cost of a lighting system must be compared with the fixed charges on the expenditure for the new addition to the plant, and nightwork be given consideration.

Careful studies into this problem show that the cost of light is usually a good deal less than the fixed charges on a new building, or than the rental for additional space. Furthermore, with modern lamps and methods of lighting, the illumination conditions at night can be made practically as good as those from natural light by day, so that the old prejudice against night work due to poor light no longer holds in the modern plant.

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## LIGHTING CURTAILMENTS IN THE UNITED STATES.

IN a discussion on the above subject before the Illuminating Engineering Society (U.S.A.) on February 16th, Mr. P. S. Millar pointed out the desirability of preventing waste and extravagance in lighting. At the same time the cost of artificial lighting of all kinds formed only ½—2 per cent. of the total expenditure of the people, being about the same as the amount spent on tobacco, and less than that spent on drink. Only about 2 per cent. of the coal produced was employed for electric light.

| Class of Lighting. | Per cent. of total lighting. | Desirable adjustment. |
|---|---|---|
| | % | % |
| Streets .. .. .. | 15 | — 5 |
| Public buildings .. | 3 | — 10 |
| Industrial .. .. | 18 | + 50 |
| Protective .. .. | 1 | +200 |
| Commercial .. .. | 20 | — 20 |
| Residences .. .. | 26 | — 20 |
| Recreational .. .. | 7 | — 40 |
| Advertising .. .. | 5 | — 80 |
| Miscellaneous .. .. | 5 | — 10 |
| | 100 | *Net* —7 |

A consensus of opinions of 14 lighting experts showed that prior to the war the amount of light used for certain purposes, *e.g.*, industrial illumination was too low, while in other cases, *e.g.*, in protective lighting of important buildings, bridges, etc., there had necessarily been an increase since the outbreak of war. Experiments in a factory had shown that trebling the artificial illumination increased the output by 15 per cent.

The adjustments recommended by the author for curtailment of light are tabulated in the preceding column.

Applied to coal a net saving of 7 per cent. means 840,000 tons per annum.

In this connection the following statistical data were presented :—

| | Tons, coal. |
|---|---|
| Total saving which must be accomplished .. .. .. .. | 50,000,000 |
| Net saving desirable through curtailment of electric lighting .. | 840,000 |
| Saving if one degree lower temperature adopted for interiors, *i.e.*, 69 instead of 70 .. .. | 3,000,000 |
| Saving if each family decreases by one shovelful its daily use of coal | 15,000,000 |

In curtailing artificial light to effect coal savings the important thing is to eliminate waste of light. Unnecessary lamps should be removed, lamps should be carefully extinguished when not needed, and inefficient lamps should be replaced by efficient types. The use of suitable reflectors, careful cleaning of lamps and reflectors, and the use of good light-reflecting surfaces are other means of effecting saving. Only in the utmost extremity should a saving be accomplished at the risk of diminished safety, reduced industrial output, and liability to impairment of vision.

# TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

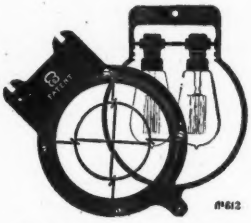
## A NEW BULKHEAD FITTING.

As an instance of the scope that exists for the improvement of apparatus which has been for years accepted as standard, and as such not open for improvement, the Wilkinson Patent Balkhead Fitting is an illuminating example in more senses than one.

Since the days of the earliest carbon lamps one has been accustomed to the regulation bulkhead fitting, and no one seems to have thought it necessary to improve it.

The Wilkinson Bulkhead Fitting makes one realise how much the old type of bulkhead fitting is out of date—as much so as the carbon filament lamp, for which it was originally designed. Such great developments have taken place in lamps and wiring methods that nothing short of a complete re-design has been necessary to put the bulkhead fitting into line with modern requirements.

No 612, closed.



No. 612, shewing method of opening.

The principal features claimed are facility of installation, easy wiring—looping-in in particular—centralisation of the filament, no hinges to corrode, easy removal of the lid without dropping it, and in two of the types the facility to use either one or two 40 or 60 watt lamps at will. They are particularly suitable for ship use and chemical works. No. 610 is suitable for one, and No. 612 for either one or two lamps.

No. 614, in perspective. No. 614, in section.

A special pattern, No. 614, is made for use in, or rather outside of, danger buildings, to project the light through the window, the door being at the back, so that the lamp may be renewed without disturbing the fitting itself.

The sole makers are the Wardle Engineering Co., Ltd., 196, Deansgate, Manchester; and 25, Victoria Street, London, S.W.1.

## AMALGAMATION OF MESSRS. WHITTAKER AND CO. AND SIR ISAAC PITMAN AND SONS, LTD.

Messrs. Whittaker and Co., the well-known firm of scientific and technical book publishers, of 2, White Hart Street, E.C.4, has been incorporated with Sir Isaac Pitman and Sons, Ltd., as from the 1st January, 1918. Mr. A. J. Rayment, the sole surviving partner in Messrs. Whittaker and Co., will continue to supervise the publication of new technical works for Sir Isaac Pitman and Sons, Ltd., so that there will be no kind of break in the management or organisation of the business which has now become a special department at No. 1, Amen Corner.

## APPLICATIONS OF "ARTIFICIAL DAYLIGHT."

WE have received from Mr. M. Luckiesh an illustrated booklet issued by the Nela Specialities Division (National Lamp Works of the General Electric Co., Cleveland, U.S.A.), describing various applications of the various electric units designed to produce their light very similar to normal daylight. We are also indebted to Mr. Luckiesh for the illustrations accompanying this note.

There is some difficulty in defining exactly what is meant by "standard daylight," but it is stated that by a series of observations throughout the year a close approximation to the average quality of natural illumination can be made; naturally this quantity would not be quite the same in different localities, in a clear atmosphere and in a foggy city.

FIG 2.—New York Cotton Exchange. Classification Room illuminated by Nela colour-matching units of the precision pattern.

Following these experiments a series of units has been prepared, some for producing a general illumination where not very great accuracy is needed, others designed to imitate daylight very closely (presumably with some sacrifice in efficiency to gain this result).

Fig. 1 showing a shop window illuminated by concealed daylight units of the former approximate kind consisting of electric incandescent lamps, with coloured lamp bulbs (Mazda C2). These units are only regarded as approximate, but serve for display purposes, and are relatively inexpensive. The lamps themselves are screened from view in the approved manner.

Fig. 2, on the other hand, shows the special precision units for accurate colour-matching operations, as employed in the New York Cotton Exchange.

A third type of unit utilises enclosing glass globes of two-colour standards (Trutint) in various shapes and styles, which can be used with any ordinary lamps at rated voltage, and enable the method to be conveniently applied to indirect lighting, thus making the impression very similar to that produced by ordinary daylight.

Fig. 3 will serve to show the variety of artificial daylight units now available. Of these Nos. 734 and 796 are the accurate colour-matching units. The others represent various "Trutint" glass units for general use.

There are many applications for units of this kind, such as picture galleries, cigar factories, tailors and haberdashers, paint factories, florists, dye-works, etc. The Cleveland Museum of Art, finished in 1916, is spoken of as one of the best examples of such lighting, daylight units being applied and special attention devoted to the elimination of glare, and the avoidance of reflection from pictures. The effect is said to bear a striking resemblance to natural illumination.

Finally there is a special form of lamp (Mazda C3) designed especially for photographic purposes. The blue bulb of this lamp is of such composition as to allow actinic values to pass freely but to filter out a portion of the visible reds and yellows.

It will be seen, therefore, that the application of electric "artificial daylight" units appears to be becoming standardised in the United States, and in the future more will doubtless be heard of them in this country.

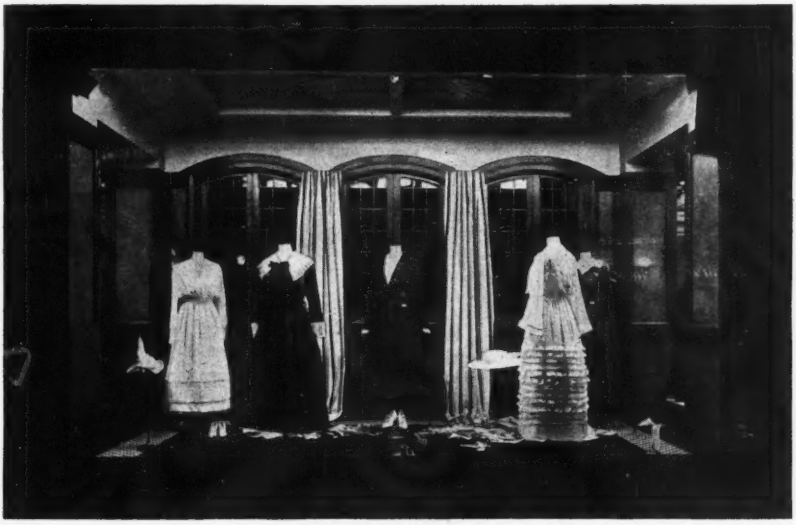


FIG. 1.—A Show Window effectively lighted with Mazda C2 lamps, giving a resemblance to daylight and suitable for displaying colours.

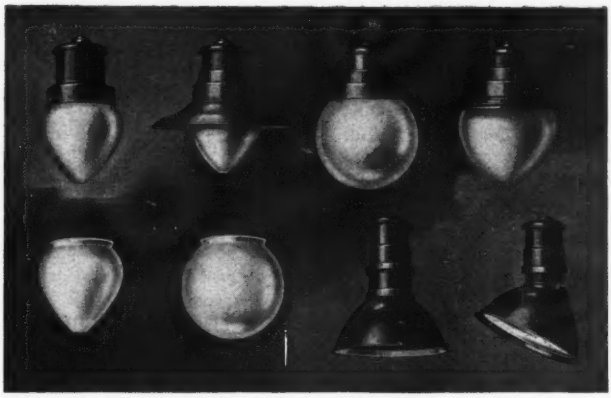


FIG. 3.—A group of artificial daylight fixtures showing variety of styles now available. Nos. 734 and 796 are accurate colour-matching units, the remainder are "Truetint" glass for general illumination.

## MAZDALUX METAL REFLECTORS.

THE list under the above title issued by the **British Thomson Houston Co., Ltd.** (Mazda House, 77, Upper Thames Street, London, E.C.), for January in the present year is again a well-got-up and useful production.

The grouping of the matter illustrates, at a glance, the chief features of any reflector; the illustration of the fitting, its polar curve, and particulars of prices and dimensions being given on the left-hand page, while photographs of installations making use of the units, taken solely by artificial light, are shown on the right. These illustrations are selected to deal with various aspects of illumination, and include installations in factories, mills, shops, churches, etc. Early in the pamphlet we note the ingenious illumination charts for illuminating engineers, showing the appropriate spacing and type of reflector for typical plans for installations, to which we have referred previously in these columns. The list is completed by particulars of hooks, insulating suspenders and other accessories for lighting units.

## "DON'TS" FOR CYCLISTS.

ONE of the very useful posters prepared by the London "Safety First" Council shows, by the aid of photographs, some of the chief errors to be avoided by cyclists in traffic. During the war, it is stated, more than 110 cyclists have been killed and 1,700 injured in the streets of the Metropolitan area. The need for a wider knowledge of precautions to be taken in London traffic is evident, and we congratulate the Council on this typical example of the good work they are doing in the interests of safety.

## WOTAN LAMPS ON L.C.C. TRAMCARS.

**Messrs. Siemens Brothers Dynamo Works, Ltd.**, 38 and 39, Upper Thames Street, E.C.4, advise us that Wotan Traction Type Lamps have been adopted for use on the L.C.C. tramcars. A contract has, therefore, been placed with them to cover the total requirements for the ensuing twelve months, and the number of lamps required will be approximately 150,000.

## THE WOTAN PENCIL ECONOMISER.

WE have received from **Messrs. Siemens Bros. Dynamo Works, Ltd.**, a simple and ingenious "Wotan pencil economiser," which consists in an outer sheath, finished black, in which the pencil is inserted so that only the pointed extremity projects. As the pencil wears away it can be pressed back into the sheath, and it is thus possible to use it completely down to the last inch. These pencil economisers can be obtained in the ordinary way through Siemens branch organisations, or by application (enclosing a business card) to headquarters at Upper Thames Street.

## FITTINGS FOR HALF-WATT LAMPS.

A LIST issued by the **Engineering and Arc Lamps, Ltd.** (St. Albans), shows a series of useful lanterns for use with half-watt lamps, as well as units for indirect and semi-indirect lighting, shop-window illumination, etc. Special importance is attached to the provision of adequate ventilation and weather-proof design.

## "USEFUL TABLES."

A SMALL booklet under the above title is issued by **Messrs. Babcock and Willcox, Ltd.** (Oriel House, Farringdon Street, London, E.C.). In the 6th edition, which we have before us, the tables have been revised and re-edited. Among other matters dealt with we note Stress Conversion Tables, Properties of Saturated Steam, Specific Heats, Densities, and data relating to the velocity of streams of air escaping under pressure and draughts in chimneys, etc.

## "THE SUNIC RECORD."

THE *Sunic Record* for January, edited by Mr. T. Thorne Baker, deals in a popular manner with the manufacture and properties of induction coils, fluorescent screens for radiographic work, dangers in the Röntgen Laboratory and other matters relating to X-ray work. The issue is concluded by an account of the X-ray plate in practice in which the development of such plates is discussed.

# CORRESPONDENCE.

## THE LUMEN.

DEAR SIR,—

I have read the lucid analogy given by the British Thomson Houston Co., Ltd., and published in your September edition (1917), between the behaviour of a pump and a source of light.

It is a pity, however, that it has been spoiled by loose technical expressions, *e.g.*, stating that a lamp generates 600 lumens. A lumen is the effect of a light source upon a plane at unit distance from that light source, *i.e.*, the lamp *delivers* 600 lumens in exactly the same way as the pump. It is further stated that some lamps require more "energy" (watts) to generate the same number of lumens. "Energy" is "watt-hours"; the "watt" is the unit of power.

The article goes on to state that the mean spherical candlepower is only an imaginary quantity. Mean spherical candlepower can be accurately measured by direct means and is anything but an imaginary quantity. The determination or calculation is no more tedious than the determination of the lumen. Lamp manufacturers have only adopted the lumen as the secondary rating for gas-filled lamps, the watt-rating still remaining as in the past.

It is rather a pity that it should be found necessary to condemn existing units in order to support this new secondary rating for lamps. If the lumen is so simple to understand why does it require such a large amount of education to make it known? The mean spherical candlepower, or as some prefer to call it, the "average candlepower" never required advertising to make it comprehensible to the lay mind.

Yours faithfully,

"AVERAGE CANDLE-POWER."

DEAR SIR,

The communication from "Average Candlepower" which you have kindly submitted to me for reply contests the statement that the mean spherical candlepower is an imaginary quantity. Yet this statement is obviously true, in the sense that no lamp *actually furnishes* the mean spherical candlepower assigned to it. This would only be possible in the case of a source radiating uniformly in all directions. It is true that it is capable of precise definition, and that it can be accurately determined in the laboratory, but it is essentially a "hypothetical" quantity none the less. On the other hand every lamp *actually does* yield a certain flux of light in lumens, which is independent of the manner in which the light is distributed, and has an actual value in illuminating engineering calculations.

For this reason, as well as for others, the lumen is really an easier conception to explain than mean spherical candlepower. It is easy to show that the total flux of light from a source is obtained by adding up the fluxes in each successive zone. Thus it really represents the total output of light. On the other hand, in order to explain mean spherical candlepower you have to state that it is the candlepower which the lamp would furnish if it gave as much light as at present, but distributed evenly in all directions. This at once calls for the exercise of an effort of imagination. Further, when the polar curve of light distribution is presented it next becomes necessary to explain why the mean spherical candlepower cannot be obtained by taking the average of the polar co-ordinates. It is a common mistake (from which I trust your correspondent is free) to assume that this can be done and the term "average candlepower" is a direct and wholly misleading invitation to endeavour to "average" the candlepower by this process.

I do not agree that the mean spherical candlepower is, even now, comprehensible to the lay mind, although it has been in use for so many years. To photometric experts it is naturally familiar, but the ordinary consumer has no conception what it means, and is usually mystified

by any attempt to explain it in any but a very loose and perfunctory manner.

Considering the short time during which attempts have been made to popularise the lumen it has become familiar more quickly than might have been expected, whereas in the early stages of photometry mistakes were not infrequently made, even by experts, in connection with mean spherical candlepower.

It should be no more difficult to determine flux of light experimentally than the mean spherical candlepower; in fact, it is really necessary to obtain the former in order to deduce the latter. The use of the integrating sphere has already yielded promising results for the rapid determination of flux of light, and is already so used by several companies in the United States and England; in fact in the October issue of THE ILLUMINATING ENGINEER reference was made to its application for determining the efficiency of projection units, certainly a very severe test of the accuracy of the method. Experience shows that this method can be quite expeditiously and accurately applied to incandescent lamps, and is being so applied by lamp factories in several countries.

The statement that "lamp manufacturers in Great Britain have only adopted the lumen as a secondary rating for gas-filled lamps" is not exactly a correct statement.

The leading British lamp manufacturers have agreed to adopt the lumen as the unit for expressing luminous values for electric lamps as a better and more exact unit than candlepower. In carrying out this plan, particularly under war conditions, the first practical step was to adopt lumen values for the gas-filled lamps for which no previous candlepower values had been formulated, owing to the complications of candlepower ratings for such lamps. In the ordinary vacuum type lamps where candlepower values have been formulated for some years, lumen values are now to be given in addition to the candlepower values.

Lumen values are therefore being adopted and published for metal filament lamps in vacuum type as well as gas-filled type.

While the watt rating remains as the *fixed* size rating, it is not exactly correct to consider the lumen rating as a *secondary* rating only. For the purpose of expressing luminous values where these are required, the lumen is *the unit*, just as for the purpose of expressing sizes of lamps (which is all that is ordinarily required by lamp users) total watts is the unit. Total watts remain as the fixed value for sizes of lamps and the lumen values are derivative therefrom according to the efficiency of the lamps at the particular time. The lumen is only secondary in this sense, that it is derivative from the fixed total watts size rating.

It is not secondary in any other sense as the lumen is for its particular purpose—the expression of luminous values, *not* a secondary unit but the preferred and most desirable unit all things considered.

Lumen values or candlepower values are not often required as the average lamp-user does not care much about knowing the luminous values of his lamp as long as he gets a certain size of lamp which he knows is capable of giving the effect he wishes, and for general purposes the watt rating is the more practicable and desirable basis of sizing lamps.

Finally, your correspondent takes exception to the reference to energy as watts, and I agree that power would be the more correct expression, but this is a slip which has no bearing on the general tenor of the argument.

Yours very truly,

F. W. WILLCOX.

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## FLUORESCENCE AND PHOSPHORESCENCE.

DEAR SIR,

If not too late to be still topical, I should like to make some reply to Mr. Landau's comments in your August issue last year upon my letter on the subject of Fluorescence and Phosphorescence.

Mr. Landau's criticism seems intended to destroy any attempt at a consistent theory of luminescence, by dwelling on the debatability of definitions and the ambiguity of facts. First, as to definitions. Mr. Landau has apparently confounded my definitions of fluorescence and phosphorescence with my suggestion as to the origin of the difference. But in any case arguments from etymology and historical usage cannot be decisive in a question of fact and its exact description. The fact is, that we don't first verbally distinguish fluorescence from phosphorescence, and then try to demonstrate a quantitative difference. On the contrary, we first observe a quantitative difference in reaction-time in certain examples of photo-luminescence, and then proceed to distinguish verbally between them. There is then no question as to the existence of the difference, but rather as to whether there is sufficient reason to assert a qualitative distinction.

The point at issue, however, involves something more than a verbal quibble.

Practically, in regard to both observation and application, the "time-lag" is far from being a side-issue. In the use of calcium tungstate for X-ray intensifying screens, it is essential for certain kinds of work that the rays induce fluorescence without sensible phosphorescence. "Physicist's" suggestion in your same issue as to determining exactly the persistence or after-glow has already been tried out in some measure, in the various phosphoroscopes devised by Becquerel, Wiedemann, and others. But, in the case of relatively faint and evanescent after-glows observed by intermittent illumination, the possible error due to retinal effects must be considered. Appeal to the photographic plate is also uncertain, owing to deviations from the Bunsen-Roscoe reciprocity law at low intensities, and the correlated intermittency error. Still, whilst this method of attack can hardly be decisive, it gives valuable help. I was myself formerly entirely of the opinion that fluorescence and phosphorescence were substantially identical.* My doubts on this—and perhaps Mr. Landau may lay them—have risen less as to the validity than as to the utility of this conception. They have been aroused by work on calcium (and other) tungstates, and by the comparative balance of evidence showing fluorescence more generally indicated in systems of chemically pure components, equilibrium systems, and phosphorescence where the system is in false equilibrium, containing active impurities.

Now neither Mr. Landau nor myself are thinking of a barren identity of the A = A type. What he is presumably pleading for is the continuity of fluorescence and phosphorescence, the idea that there is a necessary passage from one to another simply according to change of physical factors. But the miscellany of examples he gives does not by any means bear out this inevitable continuity, but rather exhibits a casual contingency—just what we might expect on the working hypothesis of active chemical impurities as radically affecting the type of luminescence.

That the actual mechanism of luminescence, presumably electronic, is the same in all cases is possible, although further spectroscopic and spectro photometric work upon this is very desirable, but this does not affect the issue. Nor do the examples of variable production of fluorescence and phosphorescence under different heat treatment conclusively disprove the hypothesis, since the effect here, admittedly variable, may be due to development or destruction of an impurity.

For similar reasons, X-rays are perhaps better adapted to function as simple actinic indicators than ultra violet light, owing to the greater probability of irreversible photo-chemical change with the latter. That is, I agree with Mr. Landau, that luminescence nuclei are not necessarily pre-existent; but I disagree with the view that "the permanent or evanescent nature of the nuclei has little to do with the question." Mr. Landau would give us "Hamlet" without the Prince of Denmark.

As to the nature of the nuclei, this is less a subject for speculation than for spectroscopy. Data from this will show how far the luminescence is due to free atoms, how far affected by chemical combination—including in this the so-called changes of physical state, which are also changes in state of chemical combination. On the chemical impurity hypothesis, phosphorescence or after-glow is a sign of delay of adjustment of specific photochemical equilibria, an adjustment which is instantly reversible in fluorescence, but only pseudo-reversible in phosphorescence. The phenomena of fatigue are in agreement with the view that chemical catalysis is involved.

I have nowhere stated that the crystalline solid condition is essential to the development of luminescence in general. What I drew attention to was the apparent connection between incipient crystallisation of calcium tungstate and the development of pure fluorescence in X-rays. I have regarded the crystallisation here as an indication of development of inner chemical equilibrium-approach to saturation of affinities, or, in terms of analytical chemistry, as a sign of the purification of the system. But that does not exclude the development of luminescence in non-crystalline systems, nor is that a necessary deduction from my suggestion in the special case of calcium tungstate in X-rays. I am glad that Mr. Landau agrees with me on the basic fact of an impurity inducing the passage from fluorescence to phosphorescence here, though differing as to its nature. And here I should like to amplify a previous statement. It is now possible to obtain crystallised calcium tungstate by wet way precipitation, under special conditions, which is luminescent in X-rays. Further, the conditions of its pro-

* S. E. Sheppard, *Photochemistry* (Longmans, 1914), p. 398.

duction favour the chemical hypothesis advanced, in that by a traditional method of purification, by fractional crystallisation, the fluorescence may be enhanced, the phosphorescence suppressed.

The mysteriousness of crystallisation is a somewhat unhappy phrase, if it be intended to imply that exact scientific knowledge of the process and the state is lacking. On the contrary, there is a great deal positively known as to the process, whilst the mathematical and optical theory of the crystalline state has been amazingly amplified by the direct crystal analysis initiated by Laue* and developed by the Braggs.† Further, the work of Nichols and Merritt‡ and of Howes* shows that in the case of the low-temperature banded fluorescence spectra of the uranyl double salts, nature of the bands is profoundly affected by water of crystallisation, and the position of the bands by the crystalline system.

In the case of radio-activity, the hypothesis of atomic disintegration proved a sword capable of cutting the knots. An adequate hypothesis in the case of luminescence is perhaps not yet available, and the suggestions proffered are only submitted with the hope of helping its arrival.

Yours very truly,

S G. SHEPPARD.

Research Laboratory,
Eastman Kodak Co., Rochester, N.J.

* *Sitz- Cer. d. Bayer Apid. d. Wis., June*, 1912.

† *Proc. Camb. Phil. Soc.* 17, 43 (1912).

‡ *Phys. Rev.* (1) 33, *p.* 375 (1911).

**Phys. Rev.* (2) 10, *p.* 348 (1917.)

## REVIEWS OF BOOKS.

*The Electrical Engineer's Diary* (1918). *Edited by J. H. Johnson, M.I.E.E.* (*S. Davis and Co.*, 30 *and* 31, *St. Swithin's Lane, E.C.* 6*s.*)

*The Electrical Engineer's Diary* for 1918 is not only up to the standard of previous issues, but we note that further developments in the electrical industry have necessitated a considerable increase in the number of pages.

Readers of this journal will be interested in the sections on lighting, especially that dealing with industrial illumination, which occupies 35 pages, and is appropriately followed by a series of "don'ts" for contractors, many of which apply specifically to lighting.

It is difficult to select from the variety of information under the headings of The Generation of Electricity, The Application of Electricity for Lighting Power Purposes, The Installation of Telephones and Bells, The Applications of Electricity for Cooking and Heating, and the very wide range of subjects grouped under General Information. It is enough to say that the Diary is a most useful companion to architects, engineers, and contractors. If in the next edition yet further expansion is possible, we should like to see the section on welding and electric furnaces treated somewhat more fully. This is a very progressive subject, on which detailed information is difficult to obtain.

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## PROFESSOR SILVANUS P. THOMPSON.

### Memorial Pamphlet.

WE have received a copy of a Memorial Pamphlet to the late Professor Silvanus Thompson, which should be of interest to many readers of our journal who, in common with all concerned with the practical utilisation of light, treasure the memory of the distinguished First President of the Illuminating Engineering Society.

The pamphlet contains an Inaugural Address delivered by Professor Thompson to the students of the City and Guilds of London Technical College, Finsbury, and an introductory memoir by an old student, who is also a member of the Illuminating Engineering Society. Appreciative reference is made to Professor Thompson's versatile gifts and lovable disposition. One finds, as one might expect, that in all his dealings with students, he showed the same kindly and considerate traits that endeared him to all in the scientific world. Admirably equipped for the conveyance of scientific and technical facts, Professor Thompson had the rare gift of inspiring others with his own love of knowledge, and his influence was such that all who worked under him became not only earnest students but better men.

The Memorial Fund at the College was initiated at a General Meeting of the Finsbury Engineering and Chemical Societies called in July, 1916, when it was decided to hang an enlargement of the photograph of Professor Thompson, which forms the frontispiece of this pamphlet, in the College. This portrait has been hung and an earnest appeal is now made for further subscriptions to the fund ; these, with all profits from the sale of the pamphlet, will be handed over to the General Memorial Fund of the Old Students' Association. Subscribers are asked to state how they desire their contributions divided between the object of providing a suitable memorial for the benefit of the College which he loved and served and that of purchasing his library for the Institution of Electrical Engineers.

Copies of the Memorial (post free 2s. 6d.) can be obtained on application to the Secretary, Thompson Memorial Committee, Technical College, Leonard Street, Finsbury, London, E.C.2. No doubt some of our readers will be glad to take advantage of this opportunity to acquire this tribute to Professor Thompson, with its actual examples of his artistic and poetic powers.

The Council of the Illuminating Engineering Society is also considering the best method of recording the Society's appreciation of his great services as President during its first four years of existence.

## THE COLLEGE OF TECHNOLOGY.

The "Manchester School of Technology" will in future be known as the "Manchester College of Technology" a title which is considered more in keeping with the advanced work carried on. We are glad to observe that in spite of the war the College is making good progress, and that the proportion of students doing advanced work has doubled during 1913-1916.

## PERSONAL.

READERS will be interested to learn that Lieut. Malcolm Macfarlane, M.C., R.E., has been awarded the Military Cross for achievements in the field, at the commencement of the Cambrai action, during which he captured seventeen Germans.

Lieut. Macfarlane is a member of the Illuminating Engineering Society, and is the son of Mr. O. P. Macfarlane, a member of the Council of the Society and associated with Messrs Blanchard (British) Lamps, Ltd.

# 3

The ILLUMINATING ENGINEER

Edited by LEON GASTER

THE JOURNAL OF SCIENTIFIC ILLUMINATION.

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# EDITORIAL.

## The New Lighting Restrictions.

In our last issue we referred to the paper recently read before the Illuminating Engineering Society in the United States by Mr. Preston S. Millar on the subject of lighting curtailments, and pointed out that the amount of coal saved by any practicable general diminution in lighting was necessarily small, but that there might be other factors which would weigh with the Authorities in enforcing such a reduction.

Under an Order, dated March 26th, 1918, made by the Board of Trade, further restrictions in the consumption of gas and electricity for Lighting, Heating, and Power are now announced. The Order calls for a general reduction on the part of consumers, whose consumption for any quarter (subject to certain concessions) must not exceed five-sixths of the amount of gas and electricity for the corresponding quarter of 1916 or 1917, whichever is the greater. The Order also imposes additional restrictions on Hotels, Restaurants, Clubs, and Places of Entertainment. No cooking is to be done, and no lights (except for cleaning purposes, etc.), exhibited in dining rooms between 9.30 p.m. and 5 a.m., while in places of entertainment no gas or electricity is to be consumed on the stage or in the auditorium between 10.30 p.m. and 1 p.m. A further restriction is applied to shop-fronts, no lights being permissible except those considered necessary inside

for serving customers, or for illuminating a sign to indicate that business is carried on.

While it may be taken for granted that everyone will do his best to comply loyally with the requirements of the Authorities, we think that if undue hardship is not to be imposed, or false economy practised, a good deal of elasticity will have to be allowed in the enforcement of this Order. Certain essential premises, such as hospitals, railway stations, and goods-yards, gas and electricity works, and controlled factories are exempted. But it is obvious that in many factories which are not controlled, but which are nevertheless doing work of national value, such a reduction would present grave difficulties, and might constitute a hindrance to rapid and efficient work which would far outweigh any economy in coal likely to result. Factories on national work will no doubt be free to apply to the Board of Trade for exemption, but the cases of entirely new factories, or factories with progressively increasing operations and consumption require special treatment, with due consideration of the capacity of the local supply undertaking. The permissible consumption in such cases might be determined by properly qualified assessors, having adequate knowledge of the requirements of the processes undertaken in the factory.

As regards the private consumer, the chief difficulty will be his ignorance of his former consumption, and of the methods which may legitimately be applied to make economies. We observe that gas and electric supply companies are presented with the duty of reporting persons whose consumption exceeds that specified in the Order—surely one of the most paradoxical situations created by the war! However, this being so, the duty of enlightening consumers on the best methods of making economies will also rest to a great extent in their hands. We should like to suggest that every consumer should receive from the company, together with his account for the quarter just terminated a statement of his consumption for the corresponding quarter last year, and an indication of the reduction which he is expected to make. Few consumers understand how to read meters or estimate the consumption from lamps, stoves, etc., and the constant rise in the cost of gas and electricity has also helped to mask their actual consumption. Where several separate connections are made in one building for one consumer, it would make things easier for the consumer, and attain equally well the objects of the Order, if the amounts registered could be added together, and the desired economy effected on the whole.

Companies might also with advantage circulate to consumers simple information on the best method of making economies. We recognise that it entails extra work, but it would be to the ultimate benefit of companies to help consumers during the present crisis, and we feel sure that, in the absence of guidance, the task of enforcing the Order, or obtaining any real benefit from it, will be difficult. On the other hand, if the opportunity is taken to give consumers a little popular information on illuminating engineering, and to enable them to co-operate intelligently in the avoidance of waste of light the present task will be lightened, and an influence exerted which will be very beneficial in the future. There is reason to believe that the public will give every support to the Authorities provided that their requirements are clearly stated, and the methods by which economies can best be made are pointed out. This is a task which would be congenial to members of the Illuminating Engineering Society, and we are confident that their co-operation in this matter would be freely given.

## Methods of Directing and Concentrating Light.

The paper on the above subject, read by Lt.-Commander Haydn T. Harrison before the Illuminating Engineering Society on February 26th, contained some interesting information on projector units using incandescent lamps. The concentrated brightness of such filaments is well suited to projection work, and it is instructive to observe that by the use of suitable mirrors the author has been able to obtain a multiplication of as much as 2000 in the searchlight beam. There are two possible directions of progress, in the source and the mirrors employed with them. Such sources as the incandescent-tungsten arc, described by Lt. Mullard before the Society since the outbreak of war, have interesting possibilities, and according to some results recently recorded in Germany, it appears that very high candlepowers from gas-filled lamps are now being obtained.

As regards the design of mirrors, Lt.-Commander Harrison pointed out the advantage of enclosing up to 270° of the luminous flux from the source. This illustrates another point, the need for greater precision in specifying the " efficiency " of a mirror or reflector. Clearly efficiency in the sense of securing a maximum proportion of the light available in the projected beam, which is best attained by enclosing the lamp as completely as possible, is not necessarily the same as efficiency in the sense of minimum absorption of light. Lt.-Commander Harrison in general prefers mirrors to prismatic lens devices for projection. There may, however, be special cases in which the latter are preferable, or are useful in conjunction with mirrors, for example, in the incandescent unit for cinematograph work developed in the United States, which was recently described in the *General Electric Review* (U.S.A.).

In the design of motor-car headlights, again, the lens is an important item. This is a wide subject which will require close attention after the war, when the present restrictions are removed. We shall then no doubt benefit by the experience of the United States, where authorities have been endeavouring to reduce the varied regulations to a simpler form, and to evolve headlights which meet requirements as regards avoidance of glare and yet provide sufficient illumination on the road-surface. The conditions desirable in well-lighted urban thoroughfares and country roads may not be the same, and the suggestion of the author that the motorist should be permitted to adapt his headlights to the two conditions, switching off or diminishing lights of undue power when entering the crowded streets of a town, deserves consideration.

In the final section of his paper Lt.-Commander Harrison put forward some novel suggestions for interior lighting, involving the use of concentrated beams of light. In the United States flood-lighting has found many new applications since the outbreak of war, and its use for exterior illumination will no doubt receive much more attention here in the future. Its application to indoor lighting is a matter that requires careful study. There is much to be learned in the use of reflection from light diffusing surfaces in interiors, particularly in the control of the distribution of light, and the study of the conditions which give rise to pleasing and artistic effects.

## Co-operation between the Illuminating Engineer and the Architect.

The application of such methods as those suggested in Lt.-Commander Harrison's paper would be helped considerably by the co-operation of the architect. For example, his participation in the planning of the lighting would enable suitable diffusing areas on ceilings or walls to be provided, so as to make the lighting device fall naturally into place with the general scheme of decoration. Similarly if the idea of using concentrating units, equipped with diffusing glass discs, were adopted he would no doubt be able to devise methods of concealing the reflector, or screening it by architectural embellishments—a method which would seem to have great possibilities for the lighting of large buildings, and especially those devoted to entertainments where a novel and striking method of illumination is desired.

This, however, is only one instance of the many directions for concerted effort between the architect and the illuminating engineer to which we have previously drawn attention. We notice that a conference was recently arranged between the German Illuminating Engineering Society and the Berlin Architects' Association in order to consider jointly practical lighting problems, comprising both natural and artificial illumination. Among the matters proposed for discussion are:—the drawbacks of insufficient illumination, especially in reference to the collection of dust in dark corners; the ill effects of glare; the waste of light through the use of unsuitable decorative devices or inefficient fixtures; the consideration of the intensity of illumination required for various classes of work; the planning of buildings with a view to the provision of sufficient natural illumination during working hours, etc. In this connection the value proposed by Cohn in 1885, 25 metre-Hefners* as a satisfactory illumination for reading and writing will be reconsidered, and a rise to 50 metre-Hefners may be recommended. A Joint Committee has been appointed to deal with these various problems. It is hoped that material progress will be made by the interchange of views, and that the committee will be valuable in paving the way for further work after the war.

We think that he time is certainly ripe for a similar step in this country. We have always been strongly impressed by the need for concerted action between the architect and the illuminating engineer, and the many pressing problems that will arise after the war render joint action very desirable. For a long time to come the need for economy in lighting and the avoidance of waste will be acutely felt. Such waste can best be avoided by agreement upon the order of illumination required for various classes of work, in factories, public buildings, schools, etc. Finally, in projected schemes of town planning illumination should play an essential part, and the whole question of street lighting will have to be reviewed after the war. The appointment of a Joint Committee now would prove of great value in preparing the way for the steps to be taken in the future.

LEON GASTER.

* Approx. 2 foot candles.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

*The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.*

# A SURVEY OF METHODS OF DIRECTING AND CONCENTRATING LIGHT.

(Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, 18, John St., Adelphi, London, W., at 5 p.m., on Tuesday, Feb. 26th, 1918.)

A MEETING of the Society took place, as stated above, on Tuesday, February 26th, THE PRESIDENT (Mr. A. P. TROTTER) being in the Chair.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of applicants for membership previously announced on January 15th, and these gentlemen were formally declared members of the Society.*

THE PRESIDENT then called upon LT.-COMMANDER HAYDN T. HARRISON, R.N.V.R., to read his paper, entitled "**A Survey of Methods of Directing and Concentrating Light**" (see pp. 72-79).

LT.-COMMANDER HARRISON prefaced his paper by remarking that there were many matters connected with the development and use of searchlights for naval and military purposes which necessarily could not be discussed at the moment, but which would no doubt receive attention at the hands of the Society after the war. Meantime, he could only deal with the general principles underlying the direction and concentration of light. The paper dealt with various types of reflectors for producing concentrated beams, and some possible applications of such devices to interior lighting.

In the ensuing discussion the following took part: THE PRESIDENT, Mr. FRANK BAILEY, Commander WADDINGTON MORRIS, Mr. J. W. T. WALSH, Mr. G. CAMPBELL, Captain PERCY T. FREEMAN, R.E., Mr. F. W. WILLCOX, Mr. A. CUNNINGTON, Mr. J. Y. FLETCHER, and Mr. J. S. DOW.

LT.-COMMANDER HARRISON having briefly replied to various points raised in the discussion, a vote of thanks to the author was moved by THE PRESIDENT and carried with acclamation.

THE PRESIDENT then announced that the **next meeting** would be held at **5 p.m., on April 16th,** when a paper on "**Light and Vision: The Physiology of the Retina**" would be read by **Professor W. M. Bayliss, F.R.S.**

* Illum. Engineer, Jan., 1918, p. 5.

# A SURVEY OF METHODS OF DIRECTING AND CONCENTRATING LIGHT.

BY LIEUT.-COMMANDER HAYDN T. HARRISON, R.N.V.R.

(Paper read at a meeting of the Society held at the House of the Royal Society of Arts, John Street, Adelphi, London, W., at 5 p.m., on Tuesday, February 26th, 1918.)

DURING some researches and experiments on the suitability of various light sources for projection purposes, and on the efficiency of various reflectors, lenses, prismatic devices, etc., intended for use with such light sources, I have encountered certain details which may interest those whose business it is to devise and manufacture means for utilising light energy to the best advantage.

It is not my intention to touch upon the principal object of my researches, namely, the projection of light for naval and military purposes, but briefly to summarise such side issues as may prove useful when considering ordinary civil or domestic applications.

Most of my work has been in connection with regular or specular reflectors, such as polished metal or silvered glass surfaces. Such reflectors follow very definite laws, and can be designed and produced on very accurate lines. It was therefore not surprising that the light sources with which they were intended to be used claimed more attention than the reflectors themselves.

Artificial light sources, to the best of my knowledge, are all diffusive in character. This has one important advantage, namely, that when the shape of a light source is known we can readily estimate or calculate the relative proportion of light emitted in various directions ; and if we also know the area of the various surfaces exposed and their intrinsic brilliancy, we can calculate the power of the rays in all directions.

Certain light sources are of very irregular formation, and some, such as flames, are even variable. But fortunately those with which we have now to deal are rarely of the latter class, and the former class, such as incandescent electric lamps and gas mantles, can be easily dealt with.

For the purpose of bringing all calculations to a common basis, I propose to avoid the use of the term " Lamberts," and deal only with intrinsic brilliancy in candle-power per square foot or square inch, which is more easily converted into foot-candles or lumens.

While on the subject of units, I would remind you that the objects of the lamp-makers and of the illuminating engineers are more closely allied than is often recognised. The electric lamp makers manufacture a device which will allow of so many feet of wire of a certain diameter (therefore a definite surface), being heated electrically so that it will produce light at, say, the rate of 1,000 c.p. per square inch of visible surface. The gas mantle makers provide, say, a square inch of fabric which can be heated by gas until it produces, say, 30 to 50 candles per square inch of visible surface. The illuminating engineer is called in to spread these surfaces of high intrinsic brilliancy over a larger area, say, in square feet. This is not as easy as it sounds, or there would not be any need for this Society to discuss this problem.

The simplest form of light sources up to quite lately has been the arc lamp consuming pure carbon. As our President demonstrated so clearly in his now historic paper of 1892, the well-known polar curve of such a lamp can be reduced to visible area of crater ; in other words, is governed by Lambert's law, bearing in mind the shadow or interruption of light caused by the negative carbon. If the negative carbon is removed and the intrinsic brilliancy of the boiling carbon crater is taken as 85,000 c.p. per square inch, it is only necessary to know the area of the crater which, when multiplied

by 85,000, will give the diameter of the cosine circle which passes through the axis of the light source. Radii struck from the point where this diameter will cut the circle indicate by their length the visible area, and therefore candle-power of the light source at any angle, as shown in Fig. 1, where A. represents the light source or crater.

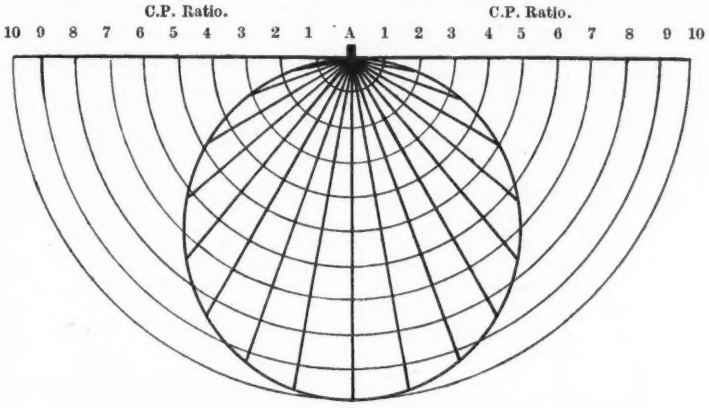


FIG. 1.—Showing distribution of light from the crater of the arc lamp.

This law is so definite that if photometric measurements when plotted give a different curve to the above, it is proof that the source of light is not a plane surface but convex. In the high candle-power searchlight lamp which has been developed during the last few years, this phenomenon occurs despite the fact that there is a very deep crater, thus proving that the light source is not the boiling carbon, but the gaseous contents of the crater, which actually boil over, and so change the plane surface into a convex shaped source of light. This law is equally applicable to incandescent lamps, gas mantles, and other direct sources of light, also to secondary sources, such as dispersive reflectors.

Take, for example, an incandescent electric lamp containing 24 inches of tungsten wire, 0·002 diameter, operating at 1,000 c.p. per square inch, which happens to be the intrinsic brilliancy of the visible part of the filament in various tungsten lamps when operated at 1·25 watts per c.p. Such a lamp would exhibit $24 \times 0{\cdot}002 = 0{\cdot}048$ square inch of surface when viewed from the horizontal, and would therefore give 48 candle-power.

I cannot sufficiently emphasise the importance of the word "visible" as used in these calculations. In the above example, the brilliancy of 1,000 c.p. per square inch is the figure quoted in all tables of intrinsic brilliancy, and it must be borne in mind that this figure is obtained by taking direct photometric measurements and dividing them by the visible area. As proof of this, if the candle-power of such a lamp were measured from the pip end it is much less, as the length of the filament is not visible from that point, but only where it crosses from support to support. Again, if it were possible to view the whole of the incandescent surface, the candle-power per square inch would not be equal to 1,000, for the light-giving area would be the length multiplied by the circumference, namely, $24 \times 0{\cdot}00628 = 0{\cdot}15$ sq. inch. Therefore, if the total luminous flux is under consideration, it would be at the rate of :—

$$\frac{48}{0{\cdot}15} = 320 \text{ c.p. per sq. inch.}$$

This, it will be noted, brings in the factor of $\pi$, which cannot be dispensed with when dealing with luminous flux or lumens.

When using reflectors this area of light source is reproduced in a varied form by

means of reflection, which projects it over various areas, the intrinsic brilliancy of which must be inversely proportionate to the area of the original light source.

Some idea of the luminous value obtained by the concentration of light can be gathered from the following table, which has been calculated by dividing the solid angle of the beam produced into the solid angle of luminous flux, which is utilised. Three examples of the latter are given, namely, 270 degrees, 180 degrees, and 90 degrees, being the equivalent of deep, medium, and shallow reflectors. The last type is that generally used in conjunction with the arc for searchlight purposes.

| Total Angle of Dispersion. | Multiplying Power of Beam. | | |
|---|---|---|---|
| Degrees. | 270°. | 180°. | 90°. |
| 1.. .. | 42,675 | 25,000 | 7,325 |
| 2.. .. | 11,380 | 6,600 | 1,950 |
| 3.. .. | 4,918 | 2,940 | 862 |
| 4.. .. | 3,798 | 1,640 | 482 |
| 5.. .. | 1,792 | 1,050 | 308 |
| 10.. .. | 448 | 262 | 77 |
| 20.. .. | — | 65 | 19 |
| 45.. .. | — | 13 | 3·86 |
| 60.. .. | — | 7·2 | 2 1 |
| 90.. .. | — | 3·4 | 1·0 |

Typical contour curves for such reflectors are shown in Fig. 2.

It is quite usual with shallow parabolic reflectors for the luminous power of the beam to reach 800 times the mean power

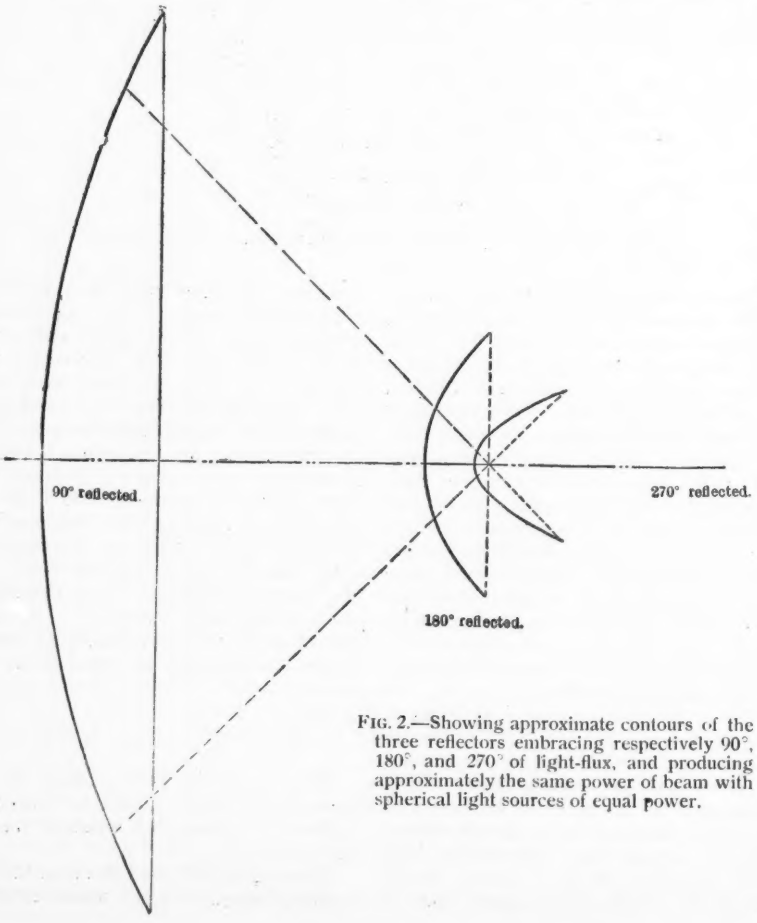


FIG. 2.—Showing approximate contours of the three reflectors embracing respectively 90°, 180°, and 270° of light-flux, and producing approximately the same power of beam with spherical light sources of equal power.

received from the lamp, showing that the usual dispersion is between three and four degrees. With the more modern lamps the luminous power is increased 1,000 to 2,000 times that of the lamp, owing to its being possible to focus the small light source to less than three degrees.

With metal reflectors of the 270-degree class, a multiplication of 2,000 can be obtained when using small incandescent lamp filaments, but such a small dispersion as five degrees is rarely required for other than signalling work.

Consideration of reflectors as secondary light sources naturally leads to their being viewed as areas having definite intrinsic brilliancy. Let us suppose that a reflector 10 in. diameter be used with a spherical light source, 0·1 in. diameter, and that the light source gives 78·54 c.p., the intrinsic brilliancy of the source, when viewed from any direction, would be :—

$$\frac{78{\cdot}54}{0{\cdot}0785} = 1{,}000 \text{ c.p. per sq. inch.}$$

The intrinsic brilliancy of the reflector would be :—

$$\frac{78{\cdot}54}{78{\cdot}54} = 1 \text{ c.p. per sq. inch.}$$

If it were possible to produce a parallel beam with such a source the same area of 78·54 square inches would have the same brilliancy at any distance.

Dispersion takes place due to the area of the light source, and as dispersion in any degree must naturally increase the diameter in proportion to the distance, it follows that it increases the area illuminated in proportion to the square of the distance.

From this the two well-known laws are derived : (1) That beams closely approaching parallel can still be considered as following the square law, provided the illumination derived from them is measured at sufficient distance to eliminate any error due to the area of the secondary source or mirror ; (2) That the luminous flux from a parabolic mirror focused to small dispersion is proportionate to the square of its area divided by the square of the area of the source.

In an important work by Jean Rey, translated from the French by J. H. Johnson, and published in England by Constable & Co., the whole of the results produced by carbon arc searchlights are based on the relative area of the crater and the mirror, which tends to show that the author was of opinion that the boiling point of carbon represented the highest intrinsic brilliancy likely to be obtained.

It has been my duty during the last few years to develop into practical form a lamp, of which the intrinsic brilliancy per unit area of light bears the relation of 250,000 to 300,000 c.p. per square inch compared with 80,000 to 90,000 c.p. with the ordinary arc. Thus it would be unwise to consider the limit of intrinsic brilliancy as having been reached, as it is obvious that future high-efficiency lamps will not depend so much on increase of temperature of the light source as upon modifications in the light wave characteristic.

Apropos of this, it is interesting to note that the progress of gas illumination is largely due to the composition of the gas mantles, which, owing to the proportioning of the constituents, have been improved nearly fifty per cent.

A polar curve of light distribution of this arc lamp is shown in Fig. 3 (p. 76).

The increase of intrinsic brilliancy of light sources more particularly affects the projection of light into narrow areas, such as used for naval and military purposes, and for flood lighting, headlights, or theatrical work. Therefore it might be considered a comparatively narrow field as regards commercial lighting. Whether this view is correct time only will decide, but I think it only right to warn those of you who are attached to the electrical branch of illumination that it is probable increased efficiency in electric lamps will result through increased intrinsic brilliancy ; and, as the intrinsic brilliancy of electric lamps is already greater than can be permitted as naked light sources, globes or reflectors will be necessary in the future, and unless much of the efficiency gained is to be lost in such globes or reflectors, it will be necessary to study carefully the laws of reflection and dispersion.

Before passing on to reflectors of other types, I would call attention to one serious disadvantage of the specular type when used in conjunction with filament lamps, namely, that they project a very clear image of the light source itself (in

other words, the filament), from which it naturally follows that the degree of illumination produced by the beam varies considerably over various parts of the illuminated area. This fault is corrected to a certain extent by using a deep parabolic reflector which, owing to the greater solid angle subtended to the luminous source, not only has a higher efficiency, but also, on account of the greater number of angles from which the luminous flux is projected, superimposes in the illuminated area more varied views or reproductions of the source, thus tending to make the resultant illumination more even.

Therefore, unless low voltage lamps with concentrated filaments can be used, it would appear that flood lighting must continue to rely upon reflectors which receive less than half the total luminous flux.

In the case of headlights, there should be no difficulty in obtaining low voltage for use with special concentrated sources. It is interesting to note that I have obtained 16-volt gas-filled lamps, averaging 100 c.p., which, with an 8-in. diameter deep reflector, gave as much as 140,000c.p. as measured by the illumination derived from the beam, and a mean of 76,000 c.p. over 6-degrees dispersion.

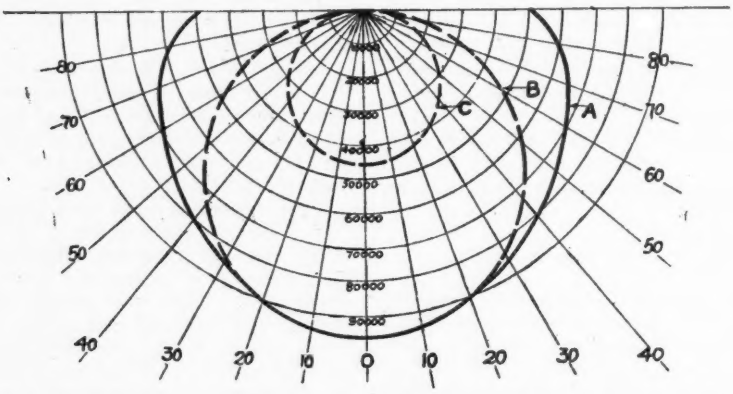


FIG. 3.—A—Typical curve of modern high intensity searchlight. B—Curve obtainable with a flat or concave light source. C—Curve, with cathode removed, given by ordinary carbon electrodes using the same electrical energy.

It is surprising that this type of reflector has not been more used for flood lighting, but probably the reason is that, with gas-filled lamps connected to the usual supply mains, the size of the bulbs would result in the reflectors having to be of deep focus, and therefore of considerable area. Nevertheless, it would appear that efficiency has been sacrificed to a serious extent, and this is witnessed by the figures published by L. C. Porter, Illuminating Engineering Society, U.S.A., June, 1917, which showed that with a 6-volt, 100-watt lamp more than double the beam power is produced than with a 32-volt lamp of the same candle-power when used in a 16-in. reflector of 3-in. focus.

It may be argued that powerful headlights of this nature will never be adopted on account of glare. This time only will prove, but it is submitted that such headlights should be allowed outside crowded thoroughfares, on condition that the power is reduced, and the divergence increased directly pedestrian or vehicular traffic is seen approaching. The power of such lamps would allow of this being done in ample time to save inconvenience from glare, and would have the advantage that accidents would be prevented by obstacles becoming visible in time to avoid them.

As regards the use of lenses or prismatic combinations in place of, or in conjunction with, reflectors, a long series of

tests on those at present available has satisfied me that for projection work short focus lenses and prisms have two disadvantages: (A) light absorption, due to thickness of glass; (B) cost, when a lens is combined with annular prisms, as in the Fresnol combination.

From the above remarks it must not be taken that I in any way depreciate the use of lenses or prismatic devices for concentrating light, but I would submit that to make these successful the lenses and prisms must be small in order to reduce their thickness. Prismatic globes and bands appear to have a considerable future before them, provided the prisms are certainly not larger than those commonly found in Holophane glassware; and if this branch of the art can be developed by reducing the size of the prisms and the accuracy of their formation, there is little doubt that such contrivances could be advantageously extended to a much greater field than is at present possible.

The importance of reducing the area of the light source, and of providing one of simple plane or spherical shape, makes the "Pointolite" lamp, as manufactured by Edison & Swan, one worthy of considerable attention. A lamp such as this, with a perfect spherical light source of small area, has proved of great value to me when testing reflectors of all descriptions. All irregularity in the illuminating power of the resultant beam disappears, with the exception that the luminous flux in the centre is reduced, due to the two thicknesses of glass through which the beam has to pass. If it were not for the fact that this is an arc lamp, and therefore only capable of absorbing 50 to 60 volts, whereas the supply pressure available is generally nearer 200 volts, this lamp would certainly be the most efficient small light unit for use with concentrating reflectors or similar devices.

With irregularly shaped light sources the use of translucent globes or screens having internal reflecting surfaces is not so satisfactory as with small sources. It is therefore probable that gas-filled incandescent lamps with their highly concentrated filaments will make possible the use of many directive and diffusing devices which have proved very unsuitable when used in conjunction with vacuum lamps, owing to the large area over which the light source of the latter is spread. For example, a specular reflector shaped on parabolic lines can be made to concentrate two-thirds of the luminous flux from a half-watt lamp on to a 12 in. or 14 in. disc of ground or other suitable glass. This surface becomes diffusive, and is therefore suitable for illuminating most interiors from the ceiling. The intrinsic brilliancy of the surface can be regulated by a suitable choice of area. Therefore, without an undue loss of efficiency, the very brilliant gas-filled lamps of to-day can, by this simple contrivance, be converted into a pleasing and efficient illuminating device for interior lighting.

The use of diffusive reflectors to attain the same object, unless of the indirect class, postulates that the light source is visible in certain positions. In order to overcome this, it is usual to make the reflector as deep as possible, thus reducing the angle over which the original light source is visible. By such means it is possible to increase the light flux at angles 30 to 45 degrees below the horizontal to double or even increase two and a half times the mean spherical candle-power of the source. Such reflectors have been very generally adopted, and give excellent results when judiciously spaced. Moreover, they have the advantage of re-directing all upward rays into the required direction; therefore they are specially suitable for factories and other places where glass roofs make it essential that no light should escape in these days of air raids, and in positions where it is impossible to use the ceilings as reflecting surfaces.

Nevertheless, the use of ceilings as secondary light sources as in the case of indirect lighting, will probably be largely developed after the war, as the great disadvantage of this system, namely, lack of efficiency, is largely wiped out by the great increase in the efficiency of the original light sources.

A disadvantage of indirect lighting as carried out in many instances is excessive diffusion of the light, thus producing a flat appearance, due to lack of contrast caused by the absence of shadows.

This disadvantage can be overcome by concentrating the light source on to a

smaller area of the ceiling, which small area can be specially prepared, or covered with a suitable device, to increase its reflecting efficiency and permit of its being cleaned when necessary in order to maintain such efficiency.

At first sight it would appear unwise to concentrate light in order to diffuse it again; but the conditions are not unlike those of the supply of electrical energy, when it is often found more convenient to generate at a low pressure, transform to a high pressure to facilitate transmission to a distance, and then transform agair to a convenient pressure for domestic and other purposes.

In the case of illumination, nearly all sources diffuse their light over considerable areas, and thus may be described as low tension. To reach a distant area it is necessary to transform or concentrate into a beam form, or the equivalent of high tension. When the beam itself illuminates the object, its surface diffuses the light which thus reaches the observer. In indirect lighting a further transformation occurs. Diffused light from the source is gathered up into a reflector and projected on to a ceiling or diffuse reflecting surface. This becomes the secondary source, or transformer, which converts the concentrated rays into a diffused course similar to the original source.

All such transformations appear to have one object, namely, to raise the pressure for transmission to what becomes a dangerous pressure, and then reduce it to the limits where it is no longer dangerous. This applies equally to illumination; a light source of high intrinsic brilliancy being dangerous from an ophthalmic point of view, on account of the excessive glare. But when such a light source or beam is allowed to impinge on a diffusive or reflecting surface, thus causing the light energy to be radiated over a greater area, all danger from glare disappears.

With indirect lighting of interiors it would be supposed that, provided the upper hemispherical rays from a source shine radially on the ceiling or reflecting surface, and the lower hemispherical rays were directed on it by a reflector, the maximum possible efficiency of such a system would be attained. That this is not the case is evidenced by the indirect lighting fittings supplied by the General Electric Co. of America, which have been designed on very sound lines, and are no doubt the result of the careful study given to illumination in that country. In this system the lower hemispherical rays are concentrated by means of silvered reflectors, thus reducing the area of the secondary source. This cannot in any way increase the total flux, which follows the Lambert law, but it increases the flux which reaches the lower or occupied part of the roof.

It would therefore appear quite likely that, as the intrinsic brilliancy of light sources increases, we may find it convenient to locate such light sources in very different positions to those hitherto adopted. Flood lighting is an example of such treatment, and it is quite possible the projection of light from different sources on similar lines may be used for interior work where space will allow of its being adopted.

As an example of what is in my mind, I would suggest the use of an inverted reflector which would receive the luminous flux from, say, 270 degrees solid angle, and concentrate it into a beam having, say, five degrees divergence. This, directed on to a suitable diffusive reflecting surface on the ceiling, would produce a secondary light source similar to the crater of the arc, as shown in Fig. 1, but of greater area and lower intrinsic brilliancy. The resultant light flux would also be similar to that in Fig. 1, with the exception of the shadow of the reflector. The extent to which such shadow would affect it could be regulated by the degree of dispersion.

The resultant light flux is indicated by Fig. 4, where it is shown in a room, say, 10 feet high and $20 \times 20$ feet in area.

I think it will be agreed that the distribution of light would prove very satisfactory.

As regards the efficiency, allowing for fifteen per cent. loss in the directive reflector and twenty per cent. in the diffusive reflector, this would approach seventy per cent., which, considering that the illumination in the lower part of the room would be more than double that obtained from the source without any reflector, is equal to many of the present

methods where the light source is visible from certain positions.

The increase in efficiency of artificial light sources also tends towards the increase in power. Thus, it is not unlikely that some of what have hitherto been the favourite methods of interior illumination (such as the use of large

examples; and I think you will agree that the honourable peace to which we all look forward will bring with it great opportunities for the illuminating engineer and the legions of those who depend upon him for the best application of their manufactures.

I hope that this paper will in some way

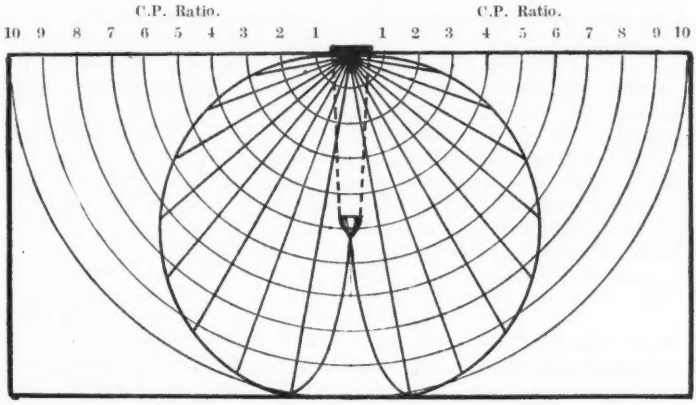


FIG. 4.—Showing method of directing light on to a small area on the ceiling, whence it is diffusely reflected into the room.

numbers of small units placed adjacent to the objects they are required to illuminate) will have to disappear, and modern schemes on quite different lines will take their place.

Many of you are no doubt contemplating such changes, and may have already evolved devices which, when the war is over, will blossom out into practical

help to direct the thoughts of those connected with illumination into channels which otherwise might have been overlooked.

I cannot claim that I have put forward any original matter, but trust that it may interest some of you by indicating the numerous ways and means of dealing with the problems of artificial illumination.

## *DISCUSSION.*

The PRESIDENT, in opening the discussion, said that the author's apology at the end of the paper was hardly necessary, for all those present were aware of the work on which he was engaged. He had, however, told them many things indirectly as illustrating the point of view from which he had to regard the subject. There was plenty of matter left over for discussion, and they would all agree that it was an extremely interesting paper.

Mr. FRANK BAILEY said that they would all look forward to the time when the author, who had made a special study of the diffusion and reflection of light, could refer more specifically to some of the matters touched upon in the paper, and he felt sure that good results would accrue from the work on which he was engaged.

A point of considerable importance was the exact position of the lamp in the reflector, for on this the illumination

derived essentially depended. It had often occurred to him that it was a disadvantage not to be able to adjust the lamp, with regard to the focal length of the reflector, and if means could be provided enabling this to be easily done it would have a most useful effect.

Commander WADDINGTON MORRIS expressed his interest in the paper. He was chiefly interested in points concerning the electrical side of the air service, such as searchlights and their application in connection with aircraft, although he was shortly leaving the electrical side for another branch of the service. He quite recognised that in the present circumstances the author was naturally unable to make detailed reference to such problems, but no doubt the information he had collected bearing on this subject would be more freely available in the future.

Mr. J. W. T. WALSH (National Physical Laboratory) congratulated the author on his excellent *resume* of the whole question of dispersion, which was a very wide subject. The section that had chiefly come under his notice was that relating to the use of prisms and lenses for the dispersion of light in such cases as ships' navigation lights. In such lights reliance had been placed on dispersion through thick lenses and prisms for the concentration of the beam in the required direction, rather than on the use of metallic or silvered glass reflectors. He agreed with the author that the reflector was more efficient, in the sense that it absorbed less light than such thick lenses, but the lenses and prisms were adopted because it was possible to maintain them in a better state of efficiency, from the optical point of view, than was the case with a reflector. In many cases the source of light was the paraffin flame, which gave rise to deterioration of the surface of a reflector in a very short time, if placed in close proximity to it. There were, therefore, cases in which the use of a thick lens-prism combination might be preferable in spite of other disadvantages.

He hoped that at a fitting opportunity the author would be able to give fuller information on his work with searchlights. In regard to Rey's book there were a number of slips which he hoped would be corrected in a subsequent edition.

He had recently been working with the correction formula for atmospheric absorption in searchlight beams. This formula, as given in Rey's book, was :—

$$I_o = I_p \frac{a^{l+l'}}{l^2} j.$$

where $I_o$ represented the illumination produced by the beam at the observer's eye, $I_p$ the illumination due to the beam at unit distance from the projector, $a$ the coefficient of transparency of the atmosphere, $l$ and $l'$ the distances of the object from the projector and the observer respectively, and $j$ the equivalent illumination of the object. $a$ was always less than unity and $(1-a)$ was in fact the proportion of the total light which was absorbed in the passage of the beam over unit distance.

In Rey's book curves were given for the evaluation of $a^{l+l'}/l^2$ for various discrete values of $l$ and $l'$, but it appeared that the easiest method of calculation was by means of a slide rule with one log scale (graduated reciprocally) working against a log scale. Such an arrangement was shown in the figure where A was the log scale, B the log log scale. If the end of A were set to a value of $a$

(0.9 in the figure), the value of $a^{l+l'}$ would be at once read on scale B against the appropriate value of $l+l'$) on scale A.

Thus in the figure if $(l+l')=7.5$, then $(0.9)^{7.5}=0.45$.

If then the other part of the rule were as in an ordinary slide rule the value of $(l+l')$ could be multiplied by the value of $I_p$ and $j$ in the ordinary way. The log scale shown at A would of course be double size as compared with the other log scales of the rule so that this scale could be used for dividing by $l^2$ directly.

It was clear that this rule could be used to find at once the value of $a$ given by any set of values of $l$, $l'$, $I_o$, $I_p$, and $j$.

Mr. G. CAMPBELL said that the paper was an excellent one and would serve as a useful record for future use, especially the remarks on the results attainable with different types of reflectors.

He was particularly struck by the author's comments on the value of reflectors of a deep type. While the advantages of such reflectors from the illuminating standpoint were illustrated in the paper it should be borne in mind that the deeper a reflector became, the more rapid was the increase in the cost of manufacture.

There was no doubt that after the war the whole question of reflectors and the new types of lamp most suitable for them would require careful study.

With the present shape of gas-filled lamps it was necessary to use a very large reflector and to place the lamp sufficiently close to the base of the reflector to obtain the distribution efficiency referred to, but such large reflectors involved considerable additional expense. The difficulty could be more easily met if makers would consider a change in the shape of lamp bulbs. The American gas-filled lamps were distinctly different in shape from the British.

In regard to indirect lighting the author had made some interesting speculations on future practice.

The present high intrinsic brilliancy of light sources and the probability that this brilliancy would continue to increase rendered the screening and diffusion of light a very important matter, and for this reason the suggestions made in the paper were of great interest. The adoption of the author's ideas would presumably involve the expenditure of a greater amount of energy than at present, because with such concentrated beams a much larger number of units would have to be employed than hitherto.

Captain P. T. FREEMAN, R.E., regretted that in the present circumstances the author was unable to deal with the many interesting problems that occurred to those concerned with the use of searchlights.

After reading the discussion on searchlights before the Society about three years ago, he had made experiments on the colour of the beam. He found, as others had done who took part in that discussion, that if one prepared carbons to give a flame-arc, the flame acted to some extent as a screen between the crater and the reflector, and the equivalent candlepower was accordingly much diminished.

There was another point which was a matter of common knowledge, namely, that in many cases it was desirable, without loss of intensity to increase the dispersion of the beam in order to search a given volume of the sky in a shorter time. In this connection he had made experiments with hollowed-out positive carbons. This gave, for the same current, a beam of larger diameter but with a dark core. An advantage was that the intensity of illumination in the outer luminous ring was not diminished, while the observer at the projector was looking at an object in the edge of the beam partly down a tunnel of darkness, and had not to look through the entire length of the beam. It was, however, an interesting but melancholy fact that carbons, as at present made would not stand this treatment. It was merely a matter of quality of carbons.

He also had found that Rey's book needed revision, but he thought that it would be a great step in the right direction if the metric system could be adopted throughout in this country.

Mr. F. W. WILLCOX (British Thomson-Houston Co., Ltd.) joined in congratulations to the author. The paper dealt with so many subjects that it could provide material for several evenings'

discussion. There were many points in the paper on which he agreed with the author and a number on which he joined issue with him. One of the well-known illuminating engineers in the United States once described illuminating engineering as the art of distributing brightness, and the paper aptly illustrated this point.

With modern lamps and lighting the question of distribution of brightness was of the first importance. These latest high efficiency lamps were many times the brilliancy of the earlier types, and it was essential that they should be used so that the light was well diffused and glare and direct light in the eye therefrom avoided. The increased brilliancy of the latest lamps (the "half-watt" type) had produced greater modifications in lighting systems than perhaps any other type of lamp since the beginning of electric lighting.

Lt.-Commander Harrison was to be congratulated on the progress in his views on indirect lighting. When the speaker read a paper on the subject before the Society some years ago, the author criticised indirect lighting, emphasising as a leading fault the high intrinsic brilliancy of the ceiling with the system. No such fault existed with properly designed indirect lighting, but the author now proceeded to the other extreme. He stated that the light on the ceiling with indirect lighting was too diffused and proposed to concentrate the light from the projector on a small spot or diffusing body on the ceiling. The resultant effect would be to produce on the ceiling, in a very aggravated form, the same fault of high intrinsic brilliancy to which the author had previously taken exception. The fault he previously attributed to indirect lighting and decried, he now created and advocated.

There was no doubt that modern high efficiency lamps had tended to popularise greatly indirect lighting. It was desirable to say a word against the tendency to speak of the inefficiency of indirect lighting. Comparisons of lighting systems were generally made upon physical values only, and such a basis was not a true measure of comparison for indirect lighting. In all comparisons of lighting systems we had to deal with the eye, *i.e.*, to consider physiological results which could not properly be expressed by mere physical values in such things as foot-candles. The ability of the eye to see was seriously impaired by glare and undue contrast in lighting. The excellent diffusion from indirect lighting and the absence of glare, ensured more than in any other system of lighting, that the eye was worked with the greatest freedom and effectiveness. Any comparison of lighting systems which failed to take into account the effect on the seeing powers of the eye was inadequate and misleading. It was for this reason that the statement was made that efficiency-comparisons, as generally made on the basis of purely physical values (foot-candles resultant illumination) were not true comparisons for indirect lighting as compared with semi-indirect or direct systems.

The speaker did not believe that the author's plan of using a searchlight projector for interior lighting would prove to be a practical or desirable method of lighting. So far as the speaker knew no such system had been developed or put into practice in Great Britain, America or the Continent. The principle of such a system seemed to be wrong, as one of the greatest advantages possessed by the approved indirect system was the utilisation of the large surface of the ceiling as a means of reflecting and diffusing the light throughout the room. To deliberately refuse this excellent arrangement and, instead of spreading the light-reflection, to concentrate it upon a small point or object on the ceiling, seems to him to be a perversion of lighting engineering methods.

As regards the curves of light distribution indicated by Lieut.-Commander Harrison on the blackboard it should be noted that the distribution of light from indirect lighting units could be altered to the desired form by using properly designed reflectors, such as are available with approved systems.

The advent of the half-watt lamps had not only introduced problems relating to intrinsic brilliancy but had involved considerable modifications in appliances, reflectors, etc., for the more effective distribution of light. The very great concentration of the filaments of the

"half-watt" type made it much easier to concentrate the light, but on the other hand made it much more difficult to obtain extensive or dispersive distributions. In fact it was physically impossible with the "half-watt" lamp to obtain, with an over-reflector alone, a true extensive distribution of light, and in order to secure this result a deflecting or refracting surface beneath the lamp must be used. Holophane refractor bowls and glass bands for this purpose were coming into extensive use for street lighting in the United States and were very effective for securing a wide angle distribution with the "half-watt" lamp.

Mr. ARTHUR CUNNINGTON, referring to the author's suggestion of lighting interiors on searchlight principles, thought the effect of the beams in a room would be rather a drawback. A searchlight beam was very conspicuous, especially if the atmosphere was at all steamy or cloudy, and there might be a similar effect in a room if the beam were very concentrated, which would not be at all pleasant. He was reminded of the effect of the atmosphere, because a winter or two ago the district in which he lived was brilliantly lighted on foggy nights by a local searchlight, although the source of light was hidden, and the beam never touched the houses, illumination being received from the surrounding atmosphere. Might it not be possible to make use of this particular effect for lighting interiors by projecting a beam through a tube, such as the Moore tube, filled with some vapour which would diffuse the light?

Mr. Willcox had referred to indirect lighting, confining himself to electric lamps. High intrinsic brilliance, however, had become general with gas lamps as well, and the type of reflector referred to by Lt.-Commander Harrison might, he thought, be used with high candlepower gas lamps, because one could easily get the inverted mantle in the focus of the reflector. He would like to know whether anything had been done to use high candlepower gas lamps with reflectors for projector purposes; he did not see why they should not be used.

It was interesting to note how the author through the paper had emphasised what the Society had been driving at for years, viz., that the characteristics (such as intrinsic brilliancy) of the original light source were not, after all, so important, and that efficiency was obtained by using high candlepower at the source, and utilising all the science of the illuminating engineer to get the best resultant effect for a particular purpose.

Mr. J. Y. FLETCHER, referring to Mr. Bailey's remarks on the correct focussing of lamps in fittings, said that this matter had been receiving a good deal of attention, but that he doubted whether much more could be done in this direction so far as vacuum lamps were concerned.

The difficulty of deciding the correct focal point of the vacuum type lamp, of which the filament was from 3 in. to 6 in. long, would be appreciated, and hence the necessity for accurate adjustment was not so important as with half 9 watt type lamps with their smaller filaments, with which the correctly designed reflector would give poor results if the lamp were not carefully adjusted.

So far as his (Mr. Fletcher's) company was concerned, the vacuum type lamps supplied could be accurately focussed both in his company's and the Holophane Company's reflector, as well as, in all probability, with other reliable well-known makes.

As regards the half-watt fittings, his company made a point of providing a means of focal adjustment, although trouble sometimes occurred through their being installed without sufficient care being taken to see that the lamp was properly adjusted in the fitting. He hoped that in the future difficulties would be eliminated by all makers producing bulbs of standard sizes. Sooner or later shapes and sizes in nearly all lamps would have to be standardised and when this was done the correct focal point could probably be marked on the reflector.

In his opinion the shape of the bulb adopted for American half-watt lamps is in some respects preferable to the British type, and he would not be surprised to see the former ultimately adopted in this country.

Mr. J. S. Dow said that the author had mentioned that the inverse square law applied roughly to searchlight beams, and that it was therefore possible to estimate roughly the illumination obtained at any distance. But, as Mr. Walsh had pointed out, in practice atmospheric absorption would be a factor of importance, and there seemed to be a surprising lack of published information on this subject. One ought at least to have a general idea of the allowance to be made for atmospheric absorption on a clear night.

Another important point on which information would be useful was the distribution of illumination throughout the beam. The dispersion depended on the area of the source of light. If polar curves were plotted with sources of increasing area (*e.g.*, arc-craters) but similar intrinsic brilliancy, one would presumably obtain a family of curves meeting on the common diameter representing maximum candle power, but progressively overlapping on either side. Had the author ever attempted to construct a series of curves of this description?

In estimating the value of a searchlight beam the tendency was to adopt methods based entirely on maximum candlepower, which depended only on the intrinsic brightness of the source and the area of the mirror. Yet for many kinds of work, when the dispersion had to be increased to illuminate a wider area, the total flux of light in the beam was of great importance. He was inclined to think that in some of the conclusions commonly advanced about searchlights there was a confusion between the maximum and the mean candlepower of the beam. For example, in an Army text-book he noticed the statement that, other factors being the same, the illumination obtained at a given distance was independent of the focus of mirror adopted. This was not in accordance with the conclusions arrived at in Rey's book, and he was inclined to think that the correct view depended on whether mean or maximum candlepower was intended.

In regard to the use of projected beams of light for interior lighting, there were certainly possibilities to be explored. He recalled an example of spectacular lighting which seemed to illustrate the author's suggestions, namely the use of a large mat white sphere, suspended in a room of considerable area and illuminated by projector-beams impinging on it from the four sides of the room, the projectors being concealed in recesses high up on the walls. The white sphere thus became the diffusing luminous source. No doubt white objects of other shapes could be applied for this purpose.

The PRESIDENT expressed the hope that the author would add plenty of diagrams to the paper as it was so much easier to visualise things from diagrams than from figures. The theory of searchlights was a subject which could be discussed at very great length some day. The Society had already had one paper on it and there were one or two books dealing with the matter, but a great deal more remained to be done. When somebody did write a book on searchlights he hoped they would bring in some of the popular newspaper theories and those of the man in the street about searchlights and their beams, because there were some very entertaining ideas to be gathered together. He had read Rey's book, and there were certainly some revisions to be made. At the same time Mr. Harrison reminded him of the fact that there was a slip in his (the speaker's) own book in which the printer had left out two zeros in the intrinsic brilliancy of the sun and the arc lamp. He had not discovered it until three years after the book was published.

With regard to Lambert's law, he did not know if any of them had read Lambert's book, published 158 years ago. He himself had spent many hours on it; it was in Latin and had never been translated into English. Lambert would be surprised if he could know the many different forms that his law took. One would think that he was a man who dealt with arc lamps, reflectors, projectors, intrinsic brilliancy and various sorts of things. What Lambert did say was that the illumination received upon a plane depended upon what we called the cosine—he called it the sine—of the angle. That was Lambert's law. One day he must give a short paper with some examples from Lambert and what he really did say.

Mr. Harrison's paper divided itself into two parts, the searchlight part, which naturally whetted one's appetite for more, and the part relating to the lighting of interiors. The proposal to project a beam on to a ceiling had some points of interest because after all when a small part of the ceiling only was illuminated, as in the case of the Institution of Civil Engineers, which was a great deal brighter than the Institution of Electrical Engineers, there was something rather attractive about it, although there were practically no shadows at all. In any form in which the whole ceiling was relied upon there were no shadows, and that had advantages and disadvantages. He thought he saw Mr. Harrison's object, viz., that by reducing the patch and getting a great brilliance there was greater liveliness in the lighting of the room.

Mr. A. WISE (*communicated*):—Deviating from the subject matter of the paper, I should like to draw attention to a point which is constantly being met with by lamp manufacturers, and which was emphasised during the discussion of the paper, viz., the disregard which is given to the source of the light and the importance attached to the reflector or diffuser. It cannot be too strongly emphasised and brought to the attention of designers of illuminating apparatus that the lamp is the more difficult object to manufacture and its manufacture is limited by certain fundamental details which cannot easily be changed; consequently the reflector, which is the more "flexible" article of the two, should be adapted to the lamp, and not, as now seems to be the general rule, the lamp to the reflector.

Lamp manufacturers have always endeavoured to work on the following principles:—

1. The reduction of the bulb to the minimum size.
2. The concentration of the filament to a minimum area.
3. A definite focus relative to the position of the cap.

Although much is still to be done in improving the above three points with a view to their general standardisation, it will be seen that an incandescent electric lamp cannot be juggled with with such ease as to obtain this or that effect under impossible conditions.

The length of filament, and hence the minimum area within which it can be enclosed, depends entirely upon the supply of electricity available and the candle-power desired.

The position of the filament in the bulb is governed to a great extent by the detrimental effect upon the life of the lamp if the filament is displaced from the centre of the bulb, the size of the bulb itself is governed by the capacity of the lamp, again with the object of making a sound commercial article of it.

I trust from the above I have made clear the importance of consulting the lamp manufacturer before designing a reflector, and then saying to him, "Here is a reflector—put me a lamp into it."

We feel Lieut.-Commander Harrison's experience will doubtless coincide with our own on this matter.

Reverting to the paper itself, there is little to criticise in the principles laid down by the author.

The lighting of interiors is based more upon the psychological effect it has upon the inhabitant than upon its scientific correctness. I am now speaking of residential interiors and not industrial interiors, and the principle which Lieut.-Commander Harrison brings to our notice of directing a powerful beam upon a comparatively small area of diffusing surface is a matter for individual taste.

The writer does not personally agree with the principle of creating strong contrasts in a room, a soft pleasant effect being far more to his taste, and this can now be easily obtained by the utilisation of the ordinary white ceiling met with in most interiors, which acts as an excellent diffusing surface.

Several methods of lending "warmth" to the totally indirect system are available, but do not come within the scope of this paper.

Lt. S. R. MULLARD, R.N.V.R. (*communicated*):—

The main suggestion put forward in the paper is of considerable interest. No doubt there are many new schemes which will be put forward after the war.

The reference to the "Pointolite" Tungsten Arc Lamp absorbing only 50

volts of the usual 220 volts supply deserves comment. The comparison only applies to concentrated filament lamps for use on ordinary lighting circuits, and the Pontolite lamp has replaced a considerable number of small carbon arcs where these were used for projection work. In many cases, however, it has also replaced tungsten lamps with concentrated filaments.

The advantages are, firstly, a perfectly steady source of light; secondly, that a concentrated source of light in small bulb is obtained, instead of a light source of comparatively large area mounted, in the case of high voltage lamps, in a large bulb; thirdly, the intrinsic brilliancy of the Pointolite lamp is more than twice that of the most concentrated filament.

As the author remarks, in order to obtain the maximum efficiency, tungsten lamps must be made with short filaments and consequently must be low voltage lamps. Moreover when burning a short tungsten filament is unevenly heated, the centre of the filament being at a higher temperature than the extremities, near the stem ends. The low voltage lamp will therefore have a shorter life than a longer filament burning at the same overall efficiency.

I hope that the desire expressed by Lieut.-Commander Haydn T. Harrison for close co-operation between the illuminating engineer and the lamp manufacturer will be realised. Such co-operation is essential. Many designs put forward by illuminating engineers do not fully take into consideration the difficulties of the lamp maker. For example, the illuminating engineer may obtain good results at the expense of the life of the lamp. As a consequence a legacy of trouble is left to the lamp maker who, ultimately discovering the cause, may reduce unnecessarily the efficiency first obtained, in order to satisfy the user by supplying a lamp with a longer life.

Mr. J. H. JOHNSON (*communicated*) :— The author is to be congratulated on giving the Society the opportunity of discussing the most important subject of light-concentration and direction.

Flood-lighting will take a prominent position in the future for outdoor illumination and, under certain conditions, indoor illumination. Whilst the low voltage high candlepower incandescent lamp, as referred to by the author, will be principally employed for indoor flood lighting, the arc lamp will be used for outdoor flood illumination.

The projector arc lamp used for this class of work has been very successfully employed at various mining centres in South Africa, the Malay States, and Australia, and in the majority of cases has proved to be superior to ordinary arc lamps when night operations are carried on continually with surface mining and other similar classes of work.

It was anticipated that serious difficulties would be met with in connection with such powerful sources of light, but provided the projectors are suitably placed in relation to the operations, all dark shadows, such as would otherwise prove to be a danger for persons moving about in the presence of obstructions, are avoided.

The modern flood-lighting projector should be capable of directing the beam at any angle, say, from 45 degrees to 60 degrees above the horizontal, in order to meet all the possible requirements. The trouble with the usual construction of the commercial projector lamp is that it does not strike automatically higher than about 45 degrees above the horizontal, and the space factor of the series coil does not permit of more turns being added to enable the arc to be struck automatically when vertical.

It has been found in many instances that by a simple re-arrangement of the magnetic circuit of the existing lamps, such as the effective air-gap and the shape of the solenoid cores, etc., a considerable increase in the effective pull was obtained with the same or a few extra ampere-turns. In a similar manner many commercial lamps have been altered to meet the conditions of anti-aircraft work.

I regret that the author was unable to give more information on the performance of the high intensity projector lamp associated with his name, although, of course, it is understood that no constructional details could be given. No doubt after the war we shall learn of the

great advances that have been made in perfecting the high intensity arc through his investigations and research.

It may be of interest to state that the effective range of a 60-in. projector with a high intensity lamp has been found to be approximately 20 miles for revealing objects, and up to about 70 to 80 miles for signalling purposes.

I fully agree with the author that future investigations will tend to increase the intrinsic brilliancy and similarly the efficiency of light production, thereby necessitating the employment of light diffusers and reflectors designed on the latest scientific lines.

With regard to the use of powerful electric headlights on motor-cars after the war, it would appear to be necessary for the lamps to be capable of movement from a central point of control so as to be adapted to the contour of the road.

I take this opportunity of remarking that there are a few errors not referred to on the errata sheet in the translation of Jean Rey's book on *The Range of Searchlight Projectors*. I communicated with the author on the subject, but owing to the urgency of the publication of this important work, there was not sufficient time for him to correct all the errors, although these will be remedied in the next edition.

Mr. H. C. WHEAT (*communicated*) :—Lt.-Commander Harrison refers to the use of specular reflectors in parabolic form for interior lighting. These reflectors would not give a suitable form of distribution, and if the contour is so modified as to meet requirements in this respect, the glare would be excessive, as the eye would see the image of the light source in the reflector. When the reflector employed has a high efficiency reflecting surface the fact that it is made deep by no means overcomes the difficulty, because the eye is often able to see the multiple image of the light source at practically the original intrinsic brilliancy. In practice much more satisfactory results are obtained by using reflectors employing a surface having dispersive or spread reflection, and in which images of the light source are not visible at all, or only at reduced brilliancy.

*Indirect Lighting.*

Lt.-Commander Harrison states that a disadvantage of indirect lighting is its inefficiency, and then he adds that this is now overcome by the increase in the efficiency of the lamps. Later on he states a theoretical case where he obtains an efficiency of 70 per cent. Now this efficiency of indirect lighting has nothing to do with the light source, and would apply equally well, presumably, to a carbon or ordinary vacuum type lamp. In his paper before the Liverpool Engineering Society of Engineers some time ago, Lt.-Commander Harrison spoke rather disparagingly of indirect lighting on the basis of efficiency, quoting a theoretical case where the efficiency was stated to be only 14·5 per cent. The writer at that time met this claim by referring to installations in his experience where the efficiency of indirect lighting was of the order of 40 per cent. Now, Lt.-Commander Harrison seems to have gone to the other extreme in claiming an efficiency of 75 per cent., which it is hard to reconcile with the estimates out before the Liverpool Society of Engineers and this Society. In order to obtain this efficiency he assumes 85 per cent. efficiency for the reflector and 80 per cent. for the ceiling, giving an over-all efficiency of 68 per cent.

Moreover, Lt.-Commander Harrison assumes a higher efficiency for a system employing a reflector enclosing the lamp 270° than for a flatter or more open type, whereas it is usually recognised that the efficiency of a unit decreases the more the reflector embraces the lamp. According to published data an efficiency of 75 per cent. is considered good for a white ceiling, leading to an over-all efficiency of about 64 per cent. The actual efficiency of properly designed scientific reflectors, of which the writer has experience (which far surpasses that of the ordinary mirror reflector) is 85—86 per cent. On the other hand, in his paper before the Liverpool Society, Lt.-Commander Harrison assumed an efficiency of only 70 per cent. for the reflector, and 70 per cent. for the ceiling, giving an over-all efficiency of 49 per cent. The writer is therefore glad to note that he has now formed a more favourable view of the efficiency obtainable from the best modern well-designed systems of indirect lighting.

Another point previously raised by Lt.-Commander Harrison, in the discussion before the Society on December 3rd, 1913, was the presumed high intrinsic brilliancy of the ceiling. In the present paper he implies that the objection to indirect lighting is due not to unduly high intrinsic brilliancy of the ceiling, but to excessive diffusion of light therefrom. In a properly designed indirect lighting system there is no high intrinsic brilliancy of the ceiling such as he feared, and the writer also considers that in any installation made with either single units or closely clustered units suspended at each point the ceiling diffusion is never excessive. Only in abnormal cases, *e.g.*, cornice lighting, does a "flat" illumination result, and one of the great advantages of well-designed indirect systems is the excellent diffusion and absence of harsh shadows.

*Use of concentrated beam on a small area of ceiling.*

In recommending the above device Lt.-Commander Harrison seems to have overlooked two points:—

(1) A small bright patch in the centre of an otherwise fairly dark ceiling is unsightly.

(2) The intrinsic brilliancy of this small area would necessarily have to be very high in order to give adequate illumination throughout the whole of the room.

Such a practice produces the condition of high intrinsic brilliancy to which Lt.-Commander Harrison previously took exception. He admits that sources of high intrinsic brilliancy are objectionable from the ophthalmic standpoint, but he surely does not appreciate the fact that excessive intrinsic brilliancy on a diffusing surface also results in glare. It is only necessary to place one's hand near a searchlight projector to realise how dazzling the light reflected therefrom may be.

The idea of using 270° reflectors is not novel, and practically represents what has been done in the "Eye-Rest" system of the company with which the writer is associated for a number of years. The chief distinction between such reflectors and those proposed by Lt.-Commander Harrison, is that the former are not parabolic in form nor designed to give anything approaching a parabolic beam.

As regards the system of lighting employed in the Louis XV. Dining Room in the Congress Hotel in Chicago, this is an Eye-Rest installation, the only unusual element being that the bowls are placed on the tops of columns instead of being suspended from the ceiling. The distribution of light is made from a comparatively divergent beam, not one concentrated on a small area of the ceiling. Manifestly it is desirable to use as much of a good white ceiling as possible for purposes of diffusion, and I think that illuminating engineering experience will confirm this practice, rather than the proposal to concentrate the light upon a small part or an object in the centre thereof.

Lieut.-Commander HARRISON, replying to the Discussion, said that Mr. Bailey had referred to a very important point as regards the use of reflectors, namely, the correct position of the lamp inside the reflector in order to obtain the desired focus. For naval and military purposes this difficulty had had to be faced, and, with the co-operation of the lamp-makers had been largely overcome. It had meant that a suitable type of cap and holder had had to be designed, and means supplied for correctly mounting the filament with reference to same. The bayonet-cap holder was unsuitable, being deficient in rigidity. Edison screw caps were more satisfactory, but, when the use of correctly designed reflectors became more universal, he thought that the makers would assist the illuminating engineers to overcome the difficulty by careful mounting of the filaments in positions standardised relatively to the cap.

Mr. Walsh had shown that the use of prismatic devices and lenses was essential for certain work. The author fully realised this, but would like to see many of the devices such as Mr. Walsh referred to designed with more numerous and smaller prisms than was the present-day practice.

Mr. Walsh had given some very interesting formula with reference to atmospheric absorption, a subject with which it was extremely difficult to deal. In

fact, the author had ceased to hypothesise or formulate on it, as he had found in practice that atmospheric conditions changed so rapidly that it was often impossible to verify, or otherwise, any data on the subject. This was particularly the case at sea, where the atmospheric conditions near the water varied largely with the distance from it.

Rey's book on the subject, referred to by Mr. Walsh, indicated a similar experience, as was noted by the frequent introduction of the "value of probability" factor. Another factor which largely entered into distance visibility was psychological: for example, the knowledge of what the eye expected to find, and the uncertainty of vision at a long distance is very striking with people who are unaccustomed to searching for objects either in adverse climatic conditions or at great distances.

Mr. Campbell's remarks with reference to the difficulty of making large reflectors were of great value, coming, as they do, from an experienced manufacturer. But the author would remind him that these large reflectors, being for powerful light sources, would be less numerous to produce the same result. Therefore, the difference in total cost might not be so much. It was also probable that they would receive more individual care and attention, and thus be kept in more efficient condition.

Capt. P. T. Freeman, R.E., had raised the question of a flame arc in which the flame acted as a screen between the crater and the reflector. Such a flame existed both with pure and treated carbons, and was probably the carbon particles cooling down as they are carried away by the air stream. The author had found that the quantity of carbon volatilised was practically the same, whether the carbons are treated or not: thus the density of the flame was much the same. But in the case of the treated carbons, the carbon particles being at a higher temperature, the flame was more visible. That it was not more opaque was shown in Fig. 3, where the maximum power occurred at a point where the flame is most dense. The flame was not visible in the beam of a searchlight, but was noticeable under it, against the surrounding darkness.

Capt. Freeman referred to a dispersed beam having a dark core. This could be obtained by a special design of mirror, but as it was also desired to narrow the beam on other occasions, which would in that case be impossible, the author favoured the use of the most efficient mirror possible for concentration, the focus being altered for dispersion.

The author would have liked to have heard more from Capt. Freeman concerning his experiments on colour of beam. There appeared to be a general idea that yellow or red rays penetrated fog better than violet or short wave lengths. It was quite possible by using correct absorption screens to cut out any wave length which might be considered undesirable, but this would cut down the illuminating value in proportion. Therefore, in order to obtain the same illuminating value, it was necessary to have a larger source of less intrinsic brilliancy and shorter wave length. Such a source could not be focussed into a narrow beam without a mirror of abnormal proportions. The chief objection to short wave lengths was that they eliminated the surrounding mist, thus producing local glare; but if the observer was at a sufficient distance from the searchlight, inconvenience from this cause was reduced.

Mr. Willcox had claimed the author as a convert to indirect lighting. He did not think that he had ever been antagonistic to the principle, but to the depressing effect of the usual means of carrying it out. The author still considered that if the whole or the greater part of a ceiling was illuminated to a very much higher degree than the rest of a room, the result would not be popular. But if the effect aimed at by the system described in the paper, namely, the illumination of a small portion of the ceiling to a degree which gave the intrinsic brilliancy usually attained by the average artificial light source, was produced, the benefits of indirect lighting would accrue without what Mr. Willcox might consider its æsthetic disadvantages.

The author failed to see how the light distribution curves of an indirect system could be modified unless the plane surface of the ceiling was altered in shape, or coated with a material which produces

to some extent a regular or specular reflecting surface.

Mr. Arthur Cunnington had raised the point that concentrated beams in smoky or moist atmospheres would be objectionable. This was quite probable, though the diffusion of light by the particles in the atmosphere might prove a pleasant alternative. The use of high candle-power gas lamps in concentrating reflectors was likely to lead to very satisfactory results, provided the reflectors were large enough, as the shape of such mantles distinctly favoured some such form of reflector.

Mr. J. Y. Fletcher's remarks were particularly gratifying, as indicating that the lamp manufacturers and the designers of fittings were getting more into touch with each other. This would not only benefit the public, but all concerned in a real advance in standardisation.

Mr. J. S. Dow expressed surprise at the lack of published information on the subject of atmospheric absorption. The author's experience was that the atmosphere round the coast of Great Britain could not be dealt with in a complete library. He had carried out tests which showed that the absorption varied every few minutes and over every few yards. Atmospheric absorption on a clear night 100 feet above the ground was negligible, and illumination of a distant object could be calculated to a nicety; but the visibility of it, depending as it does on size, colour, etc., was most difficult to calculate.

The distribution of light over a beam depended largely on three factors: the degree of dispersion, the character of the light source, and the accuracy of the mirror. The last was probably the most variable, not as regards the silvered surface, but as regards the thickness and refraction of the glass and the consistency of its value. Under these circumstances, very different results were obtained by different mirrors, even when the light sources were true spheres, accurately focussed and centred.

The author, when comparing the value of mirrors, generally based it on ratio of light flux received to light flux of beam, at the same time stating the maximum power for convenience. The focus of a mirror would also be stated, though it was largely controlled by factors outside the optical ones, such as space necessary for the lamp, light distribution from the lamp, etc.

*Added:—*

The President asked the author to add certain diagrams which will now be found to be included.

Fig. 2 gives approximately the shape, etc., of the three reflectors referred to, namely, to reflect the light flux incident over the angles of 270 degrees, 180 degrees, and 90 degrees respectively; and in order to emphasise the importance of the solid angle, the author has drawn these to sizes which are approximately proportionate to the size necessary to produce the same power beam with spherical light sources of equal power.

Fig. 3 is a typical curve of the modern searchlight referred to. The large dotted circle is inserted to show the divergence from the ordinary arc having a flat or concave crater, thus indicating that the source of light is convex, due to the light producing stream. The small dotted circle represents the profile curve (cathode removed), produced by plain carbon electrodes of the usual size and absorbing the same electrical energy.

The author regrets that he has never taken the opportunity of reading Lambert's book, but his admiration of Lambert's law was such that he preferred to call it Lambert's Law rather than designate it by the cold name of cosine.

Mr. A. Wise (communicated) lays stress on the difficulty of manufacturing lamps to suit reflectors. The author grants this, and only asks that the lamp manufacturers should clearly state their limits and stick to them. He would then be the first to tell his clients that the reflectors must be this size and this shape.

Mr. Wise then states that the lighting of interiors is based more upon the psychological effect it has on the inhabitants, which means that the reflector-maker must design to suit the lamp-maker and the public. Might not the reflector maker try to educate the public to systems of illumination based on sound principles, even if he has to let the lamp-maker have his own way? Much of the advance in methods of artificial illumination in America is due to their education propaganda.

Lt. S. R. Mullard, R.N.V.R., writes, pointing out further improvements he has made in the "Pointolite" lamp. The author has already stated how much he appreciates the value of this lamp in connection with optical work. Unfortunately, he has had no opportunity of applying it to many of the other purposes for which it must be suitable; but he would like to take this opportunity of congratulating Lt. Mullard on the successful way in which he had developed it.

Mr. H. C. Wheat (communicated) appears to have misinterpreted my paper in some respects. For example, it was not suggested that reflectors with polished parabolic surfaces would be suitable for interior lighting *per se*, but that they could be advantageously used in combination with diffusing surfaces, which would prevent the actual reflecting surface being visible to the eye, and thus eliminate glare. In fact, it will be noted that the paper specifies the methods which Mr. Wheat considers preferable.

In regard to indirect lighting the efficiency of the system should be regarded in terms of the ratio of the original flux of light which eventually reaches the object to be illuminated, rather than a factor based on the assigned reflecting powers of the various surfaces. Owing to the large illuminated area of ceiling used in most indirect lighting systems the proportion of light that reaches the lower part of the room is relatively small. By reducing this area and assigning it a central position the percentage of the luminous flux that reaches the lower part of the room can be very materially increased. While Mr. Wheat's statement that the efficiency of the light source has nothing to do with the efficiency of an indirect lighting system is obviously true in a certain limited sense, yet the extent to which a light source lends itself to use with an efficient type of reflector is clearly a point of importance, and may affect the efficiency. Thus if we are able to use a reflector which will receive 270° of the luminous flux, and direct this on to the desired area of diffusion, we shall get much more efficient results than if a comparatively shallow reflector is rendered obligatory by the type of light source employed. The loss of the luminous flux which cannot be directed by the reflector in these circumstances will diminish the efficiency of the system proportionately. Mr. Wheat also expresses disagreement with the suggestion that a more efficient result is attainable from reflectors embracing a relatively large proportion of the flux of light. There is here a confusion of terms. Assuming that a reflector is designed for the purpose of collecting as much light as possible into a beam of a certain solid angle, it is clear that the more completely the lamp is enclosed the greater the percentage of flux so directed and the higher the efficiency in this sense.

I cannot agree that the presence of a small illuminated area in the centre of the ceiling is necessarily unsightly, any more than a lamp in an ordinary reflector mounted on the ceiling, or a hemispherical opal bowl is unsightly. Nor must the intrinsic brilliancy necessarily be greater than if the entire ceiling were illuminated because, as explained previously, the distribution of light aimed at in the room is different. Mr. Wheat does not appear to attach sufficient importance to the difference between a system using divergent beams of light diffused over the ceiling, and one employing a concentrated beam of light to illuminate the centre part of the ceiling only. In the former case parts of the ceiling remote from the centre which do not need to be illuminated receive a high intensity, whereas, in the latter, areas which do not require to be illuminated are left outside the cone of reflected light, and the desired illumination in the room is thus more efficiently obtained.

The author desires to thank the numerous audience for the kind way in which they had dealt with his paper. He fears that many were disappointed that he did not deal in detail with the particular researches he has been carrying on during the last few years. He feels certain that they will realise that the publication of results must necessarily be postponed until this country and our Allies considered it advisable to publish the important research work which has been and is being continuously carried out in their service.

## LIGHTING, HEATING, AND POWER ORDER, 1918.

### Restrictions of the Use of Gas and Electricity.

THE Board of Trade have issued an Order, dated March 26th, 1918, under Regulations 2F and 2JJ of the Defence of the Realm Regulations, for the purpose of maintaining and regulating the supply of coal gas and electricity and other articles of commerce required for lighting, heating, and power purposes.

The following is the text of the Order :—

PART I.

*Operation and Definitions.*

1. This Order shall have effect on and after 2nd April, 1918.

2. Part II. of this Order applies to gas and electricity manufactured or generated within the City and County of London, the Counties of Middlesex, Kent, Surrey, Sussex, Hertford, Huntingdon, Cambridge and the Isle of Ely, Norfolk, Suffolk, Essex, Northampton and the Soke of Peterborough, Bedford, Buckingham, Oxford, Berks, Gloucester, Hampshire and the Isle of Wight, Wilts, Dorset, Somerset, Devon and Cornwall, and to the Counties of Cities or Towns and County Boroughs situate therein.

3. Parts III. and IV. of this Order apply to Great Britain.

4. (*a*) the expression "premises" means any place whatsoever other than those mentioned in paragraph 8 hereof on which gas or electricity is consumed, and any portion of premises which is supplied with gas or electricity by a separate connection shall be deemed to be separate premises.

(*b*) "A place of entertainment" means a theatre, cinematograph theatre, music and/or dancing hall, concert room, and any place to which the public are admitted for entertainments, meetings or lectures, whether for payment or not, and any club in which entertainments or lectures are given, but does not include an inn, hotel, or boarding house.

(*c*) "A shop" has the same meaning as in the Shops Act, 1912, and "a shop front" includes any portion of a shop or any show case or other similar device which is ordinarily used wholly or mainly for the display of goods to persons outside the shop.

(*d*) "A quarter of a year" means the period between the readings of the meter taken nearest to the common quarter days.

(*e*) Part II. of this Order applies to gas and electricity supplied and consumed for any purpose whatever.

PART II.

*Restriction on the Consumption of Gas and Electricity.*

5. No person shall consume or cause or permit to be consumed in any one quarter of a year on any premises of which he is the occupier more than five-sixths of the amount of gas or electricity which was consumed on the same premises during the corresponding quarter of the years 1916 or 1917, whichever was the greater; provided that—

(*a*) If the amount consumed on any premises during any quarter of 1916 or 1917 did not exceed the amounts set out in the schedule hereto against such quarter, the occupier may consume in any corresponding quarter the same amount, and no more, as he consumed in such quarter of 1916 or 1917, whichever was the greater;

(*b*) In any other case an occupier shall not be bound to reduce his consumption in any quarter below the amounts shown for such quarter in the said schedule.

(*c*) Where between the 25th March, 1917, and the 25th March, 1918, there has been on any premises a material alteration in the apparatus or fittings consuming gas or electricity the undertakers who supply such premises may and on the application of the occupier thereof shall, assess the amount that may be consumed thereon in each quarter.

In making such assessment the undertakers shall have regard to the amount which might reasonably have been consumed on such premises if the same apparatus or fittings which are on the premises at the time of the assessment had been thereon during the corresponding quarter of the year March 25th, 1917, to March 25th, 1918.

6. Where any person is or becomes the occupier of premises of which he was not the occupier in the corresponding quarter of 1917, the undertakers who supply gas or electricity to such premises shall serve upon the occupier a notice stating the amount consumed upon such premises during each quarter of 1917; and if such premises were unoccupied during any quarter or part of a quarter of the year aforesaid they shall state the estimated amount, calculated on the consumption of similar premises occupied for similar purposes in the neighbourhood which would have been consumed on such premises, and the occupier shall not consume or cause or permit to be consumed more than five-sixths of the amount shown in such notice.

Where any person is dissatisfied with the amount stated in such notice he may apply to the Board of Trade for an increased consumption, and their decision shall be final.

7. It shall be the duty of all undertakers who supply gas or electricity to report to the Board of Trade any person whose consumption

appears to exceed that permitted by this Order, due allowance being made for any difference between the dates of the reading of the meter in the quarter under consideration and in the corresponding quarter of 1916 or 1917.

8. Nothing in this part of this Order applies to any premises which are a hospital or which were being conducted as a *bona fide* nursing home on 21st March, 1918, while they are so conducted, or to any premises which are or are part of an establishment controlled under the Munitions of War Act, 1915, unless the Minister of Munitions certifies that it is unnecessary that such building should be exempted from the provisions of this Order, or to a railway station goods yard or premises used in connection with the actual working of a railway, or to premises used for cold storage, or to any place where gas or electricity is manufactured, generated, or transformed under statutory powers.

## PART III.

*Additional restrictions applicable to Hotels, Restaurants, Clubs, and Places of Entertainment.*

9. No hot meal shall be served and no food shall be cooked in any inn, hotel, restaurant, boarding house, club, hall or public eating or refreshment house between the hours of 9.30 o'clock p.m. and 5 o'clock a.m., and no light shall be exhibited in any dining-room of any such place as aforesaid between the hours of 10 o'clock p.m. and 5 o'clock a.m., except such as may be needed for the necessary cleaning and watching thereof. For the purpose of this paragraph a "dining-room" means any room furnished or adapted for the serving of meals and in which luncheons, dinners or suppers are usually served to guests, customers or members.

Provided that nothing in this paragraph shall apply to beverages served to residents, or served in railway buffets or to canteens at railway stations to which only members of His Majesty's Forces and the attendants are admitted, or to meals supplied to travelling parties of His Majesty's Forces on the Order of a Naval or Military Authority, or to private canteens at Government offices or works, or at controlled establishments or police stations.

10. No gas or electric current shall be consumed on the stage or in the auditorium of any place of entertainment between the hours of 10.30 o'clock p.m. and 1 o'clock p.m. on the following day except such as may be needed for the necessary cleaning or watching thereof, or for the purpose of a rehearsal, or exhibition of a cinematograph film to the trade, to which the public are not admitted.

11. No entertainment or lecture shall be given in any part of an inn, hotel, or boarding house which is lighted or heated by gas or electricity whether such premises hold a music and/or dancing licence or not, between the hours of 10.30 o'clock p.m. and 1 o'clock p.m. on the following day.

## PART IV.

*Lighting of Shop Fronts.*

12. No light of any description shall be used at any time in any shop front, provided that nothing in this paragraph shall be deemed to prohibit the use of:—

(*a*) Any light approved by a Chief Officer or Superintendent of Police as necessary for serving customers inside a shop.

(*b*) Any light used solely for illuminating a small sign in a shop front to indicate to persons outside that the shop is open for the serving of customers.

## PART V.

*General.*

13. The Board of Trade may grant licences on special grounds exempting any person or persons or premises of any description from the provisions of this Order for such times and subject to such conditions as may be specified in such licence.

14. Proceedings for infringements of Part II. of this Order shall not be instituted except by or by the direction of the Board of Trade or the Attorney General. Before instituting any proceedings the Board of Trade shall call upon the person affected to give an explanation of the apparent excessive consumption, and the Board shall consider any explanation offered. Provided that it shall be assumed in any prosecution unless the contrary is proved, that such explanation was called for and if offered considered before such prosecution was instituted.

15. Part II. of this Order may by notice be extended to apply to gas or electricity manufactured or generated in any place or places in England or Wales other than those mentioned in paragraph 2 hereof. Such notice shall be signed by the President of the Board of Trade or by a Secretary or Assistant Secretary thereof, and shall be published in the *London Gazette*, and shall fix a date not less than seven days from the date of the publication thereof upon which this Order is to apply to the place or places mentioned in the said notice.

16. Infringements of this Order are summary offences against the Defence of the Realm Regulations.

17. This Order may be cited as the Lighting, Heating and Power Order, 1918.

*The Schedule referred to in Paragraph 5.*

| Quarter of the year. | Gas. No. of cubic feet. | Electricity. No. of Board of Trade Units. |
|---|---|---|
| 25th Mar. to 24th June | 3,000 | 20 |
| 24th June to 29th Sept. | 3,000 | 20 |
| 29th Sept. to 25th Dec. | 3,500 | 40 |
| 25th Dec. to 25th Mar. | 3,500 | 40 |

W. F. MARWOOD,
A Secretary of the Board of Trade.

Board of Trade,
7, Whitehall Gardens, S.W.1.

## REVIEWS OF BOOKS.

*Health of the Munition Worker; Handbook prepared by the Health of Munition Workers' Committee (M.O.M.); obtainable through His Majesty's Stationery Office, Imperial House, Kingsway, London, W.C.2. 1s. 6d. net.*

THIS little handbook contains a summary of the information conveyed in the series of bulletins issued by the Health of Munition Workers' Committee. After a brief introduction there is a series of chapters dealing with the following subjects: Relation of Fatigue to Industry; Hours of Labour; Sunday Labour and Night Work; Lost Time and Incentive to Work; A Healthy Factory Environment; Washing Facilities and Baths; Seats, Clothing, etc.; The Industrial Canteen; Sickness and Accident: Protection of the Eyesight; Industrial Diseases; Welfare Supervision; Outside Factory Conditions.

Detailed information on medical certificates, canteen equipment, and other matters is given in a series of appendices and there is an adequate index at the commencement of the volume.

We have frequently referred to the extremely valuable work that has been done by the Committee for the benefit of munition workers, and the practical information conveyed in their bulletins. The importance of good illumination in relation to health, output and quality of work, and eyesight is strongly emphasised in Chapter VI. (Healthy Factory Environment), from which we recently quoted a section in this journal,* and again in Chapter XI., where it is pointed out that the important question of the eyesight of operators and its influence on efficiency of work has received far too little attention in the past.

This handbook should be studied by all concerned with the welfare of munitions and industrial workers.

## STANDARD CLAUSES FOR STREET LIGHTING SPECIFICATIONS.

The Standard Clauses for Street Lighting Specifications, drafted by the Joint Committee of the Institutions of Gas and Electrical Engineers, the Institution of County and Municipal Engineers, and the Illuminating Engineering Society, has now been issued by the Institution of Electrical Engineers (1, Albemarle Street, London, W.1.).

A Minority statement is included setting forth the views of the Council of the Institution of Gas Engineers, which preferred that contracts for street-lighting should be based on candlepower, measured at several prescribed angles, rather than on illumination on a horizontal plane 3 ft. 3 in. above the ground, as suggested. This matter was discussed in detail in a paper by Mr. A. P. Trotter before the Illuminating Engineering Society in 1913,* Agreement on the points in question has not been arrived at, but it is hoped that the Clauses will prove useful when methods of street lighting are reviewed after the war. We trust that practical experience of the specification will show that the existing differences of opinion can be reconciled, and that ultimately uniform procedure will be found practicable.

* Illum. Eng., Jan., 1918, p. 13.

* Illum. Eng., May, 1913.

## ELECTRICITY SUPPLY FROM PUBLIC MAINS.

The following announcement has been issued by the Press Bureau:—

In future, all applications to the Ministry of Munitions for Priority Certificates to enable motors and other electrical plant (requiring a supply of current from the public mains) to be purchased, should be accompanied by a certificate from the Chief Engineer or Manager of the Public Service Undertaking concerned, stating:—

(1) That adequate generating plant capacity is or is not available.

(2) That no additional cost or material is involved in connecting the premises to the mains (including sub-station equipment, if any); or

(3) Where expense is involved, the material and apparatus to be provided and the cost thereof, and whether lead covered cable is necessary or not. Where lead covered cable is deemed necessary, the voltage of the current transmitted should be stated.

Applicants should, whenever possible, also obtain the written support of the Government Department interested in their manufactures, and forward a copy of same.

The purpose of the above procedure is to reduce the demand for current—other than that used for urgent war purposes supplied by the Public Service Undertaking, and the time occupied in making inquiries.

# TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

## GLASSWARE AT THE BRITISH INDUSTRIES FAIR.

At the British Industries Fair, held in London on March 11th—22nd, glassware formed an important section of the exhibits. Apart from such sections as glass bottles and jars, filters, and fancy glass, we note that lighting glassware of various kinds was shown by the following firms: Burtles, Tate and Co., A. and J. Davies, Ltd., Duroglass, Ltd., Joseph Fleming and Co., The Lambeth Glass Works, Molineaux, Webb and Co., Ltd., John Moncrieff, Ltd., Henry G. Richardson and Sons, Stevens and Williams, Ltd., Stuart and Sons, Ltd., John Walsh, Thos. Webb and Sons, Ltd., Thos. Webb and Corbett, Ltd., and F. G. Wood. Electric lamp bulbs were shown by several of these firms and also by the Edinburgh and Leith Flint Glass Co. There were also special examples of resistant glassware for chemical work while several firms, notably John Moncrieff and Stevens and Williams, exhibited glasses for miners' lamps.

Perhaps the most impressive section of this department was the chemical and laboratory glassware, in which very considerable progress by manufacturers in this country has evidently been made. The more scientific and highly finished forms of glassware for illuminating purposes was not much in evidence, but we hope that this branch of the trade is also receiving attention from British manufacturers and that at an appropriate opportunity we shall have an opportunity of seeing more detailed exhibits of their work in this field.

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## G.E.C. "ALL-BRITISH" CARBON ELECTRODES.

A recent list issued by the General Electric Co., Ltd., contains particulars of carbons suitable for various purposes. Since the outbreak of war the demand for carbons for searchlights has been very great, but we observe that some other special types are here listed. Among these are "Apostle" carbons for open type arc lamps, "Witton" carbons for enclosed lamps, photographic units, stage arcs, etc., Flame Carbons, and "Kinarko" carbons which are specially adapted to cinematograph work.

It is common knowledge that before the war this country was very largely dependent on important imported carbons. We are glad to note that their manufacture in this country is making steady progress.

NATIONAL PHYSICAL LABORATORY TEDDINGTON

# REPORT.

Of Test on "Halo" Reflector,
For F. Holland, Esq., A.I.E.E.,
Consulting Engineer.

Measurements were obtained using an ordinary 200 V., 40 W. metallic filament lamp. The value given for any angle represents the average candle power in all directions round the lower hemisphere of the lamp making this angle with its axis.

| Direction of measurement, angle with axis of lamp, lower hemisphere. | Candle Power with "Halo" Reflector. | Candle Power without "Halo" Reflector. |
|---|---|---|
| 90° | 29.2 | 29.2 |
| 80 | 29.1 | 28.8 |
| 70 | 28.0 | 27.4 |
| 60 | 26.4 | 24.9 |
| 50 | 25.2 | 22.0 |
| 40 | 24.6 | 18.7 |
| 30 | 26.3 | 15.1 |
| 20 | 31.2 | 10.8 |
| 10 | 27.4 | 6.3 |
| 0 | 24.6 | 4.0 |

Note I.- The 90° position is taken at right angles to the axis of the lamp filaments.

Note II.- The "Halo" Reflector was placed in such a position round the lamp bulb that it was approximately level with the base of the lamp filaments.

*References*
Ph. 81. 10.
Test No.126, of 1913.
October 24th.,1913.

R. T. Glazebrook
*Director.*

Facsimile of Report issued by the National Physical Laboratory on the "Halo" Reflector.

## A 1,000-H.P. GAS TURBINE.

It was announced some time ago that the experiments at the works of the Brown-Boveri Co. at Baden had led to the design of commercially practicable gas turbines of high power, and the *Gas World* quote some particulars of a 1,000-h.p. unit of this type that is stated to have been constructed. Further experience of such new units will be followed with close interest. It is claimed that such turbines occupy only about one-third of the space required for a gas engine of equal power.

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## THE HALO REFLECTOR.

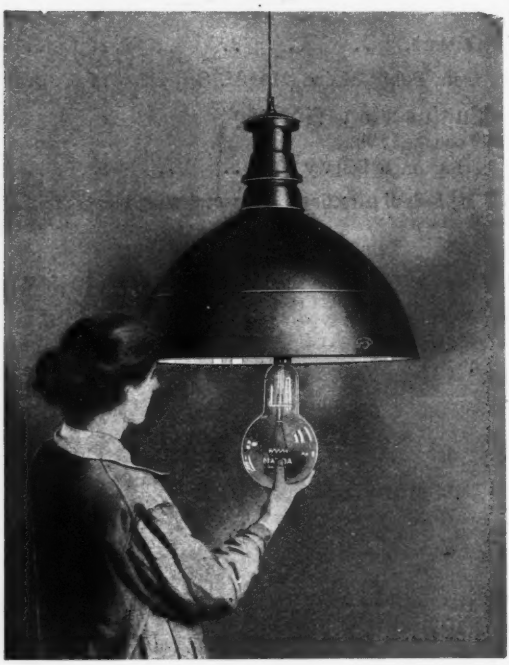
Consumers are now being asked by the Government to economise in the use of gas and electricity and to avoid, in every way possible, the waste of light. There is therefore every inducement to make good use of any devices which are likely to produce the desired illumination on the work with lamps of smaller consumption.

As is well known the distribution of light from the ordinary tungsten lamp with straight filaments requires modification by using a suitable reflector, as the candlepower in directions immediately under the lamp, where it is chiefly needed, is relatively low. At present, however, the private consumer has increasing difficulty in obtaining the standard makes of reflectors, owing to the great demand for their use in munitions works and controlled factories, and there seems an opening for simple and inexpensive devices which can be fitted on to any lamp, and can be easily removed and cleaned.

Our attention has been drawn to the "Halo" reflector, which is intended to meet this want. It consists simply of a small disc of silvered glass which can be dropped over the bulb of any lamp. According to the certificate of the National Physical Laboratory, a copy of which, furnished by the makers, faces this note, the candlepower immediately under the lamp is increased more than six times.

The device is of quite recent introduction, and no doubt other alternative forms to suit various requirements will be evolved. The reflector is manufactured by the "**Halo**" Company, 7, Exchange Buildings, St. Mary's Gate, Manchester, the special London agents and exporters being The Glass Accessories Syndicate Ltd., 28, Basinghall Street, London, E.C.2.

## MAZDALUX METAL REFLECTORS.



We referred recently to the comprehensive list issued by the **British Thomson Houston Co., Ltd.**, dealing with Mazdalux Metal Reflectors, of which a great variety are shown.

Special interest attaches to the new designs of focussing concentrating types of reflectors for half-watt lamps which are regarded as specially suitable for industrial lighting conditions. The above illustration conveys a good idea of this type of reflector as employed for 1,000-watt half-watt lamps. These reflectors are also supplied for all sizes of half-watt type lamps including the largest 1,500-watt size. A feature is the design of housings for these reflectors, which are weatherproof and give ample ventilation.

---

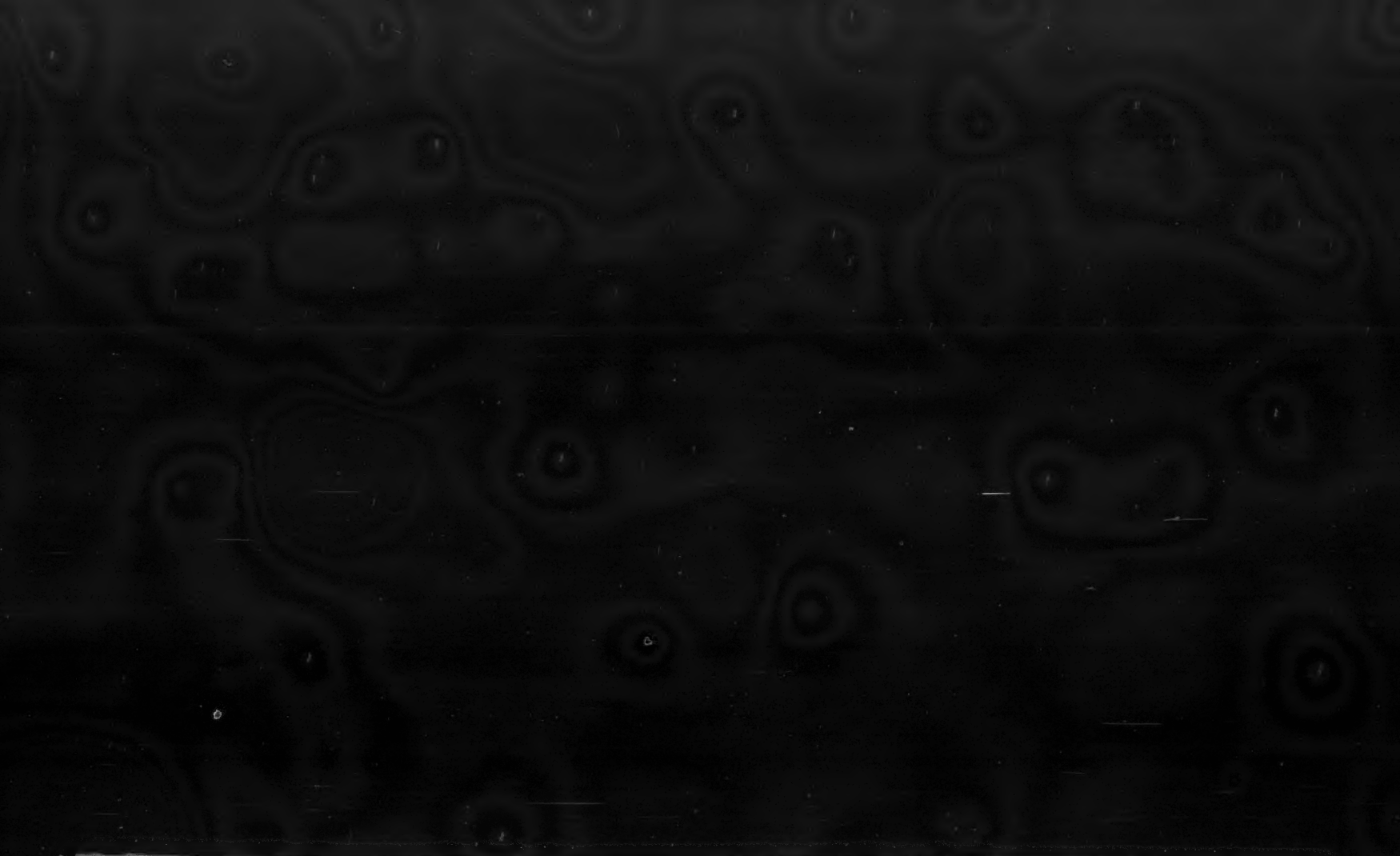
## SMALL PROJECTORS AS HELPS TO SALESMEN.

A recent leaflet issued by the National X-Ray Co. of Chicago mentions an enterprising step in the direction of securing publicity, namely, the furnishing of free lecture material on special subjects, such as show-window, industrial, and flood lighting. Lantern slides, accompanied by cards containing appropriate descriptive matter, accompany the text.

The company will also provide a small projector for the display of the slides, which can be attached to an ordinary lighting circuit, and takes only 5 ampères. It is hoped that such lectures will be useful to architects, engineers, and others interested in illuminating engineering.

The use of small projectors as an adjunct to salesmanship seems to have been receiving attention in the States, and we understand that quite a number of compact small projectors, suitable for lantern and cinematograph work, and using concentrated tungsten filaments, are available.

A lantern of this type is an obvious aid to salesmen in showing actual examples of typical lighting installations, and the cinematograph apparatus would no doubt come in very handy for the demonstration of the operation of moving machinery.



# 4

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

THE JOURNAL OF SCIENTIFIC ILLUMINATION.

OFFICIAL ORGAN OF THE

Illuminating Engineering Society.

(Founded in London, 1909.)

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# EDITORIAL.

## Light and Vision.

The Paper read by Professor Bayliss before the Illuminating Engineering Society on April 14th (see pp. 104—113), dealt with a subject of absorbing interest—the nature of vision and the perception of light by the eye. In illuminating engineering we have to deal with a long chain of effects, starting with the production of light by the illuminant, and terminating with the image of the illuminated surfaces received on the retina, and the resultant impressions formed in the brain. In considering the practical effect of any system of lighting we must turn ultimately to the impressions received by the eye. Lighting experts, therefore, should know something of the behaviour and requirements of this organ, and Professor Bayliss's paper was most useful in presenting these aspects of illuminating engineering in a succinct and attractive form.

There is still much to be learned regarding the nature of vision and the theories of physiologists and psychologists are undergoing constant revision. Some curves presented by Professor Bayliss aptly illustrated the close relation between the perception of light and the " visual principle," but the exact functions of this substance and of the " rods " and " cones " on the retina are still the subject of discussion. The conveyance of nerve-impulses to the brain-centres, and the resulting formation of impressions

therefrom is even more difficult to investigate. In the circumstances we can only marvel at the wealth of knowledge that patient research has already accumulated on such subjects.

A little knowledge of these matters will soon convince any one of the complexities and peculiar difficulty of ophthalmic research, and this no doubt is one reason why definite information, from the physiological side on problems of illumination is hard to attain. But we think it will be recognised that our lack of information on these practical points is also due to the fact that the relations between lighting experts and ophthalmic surgeons, physiologists and medical officers have not been sufficiently close, with the result that the practical importance of these problems in lighting has not been fully laid before those who are in the best position to deal with them. Professor Bayliss, in order to illustrate the need for such co-operation, enumerated a number of problems on which information is badly needed, such as the limiting brightness and contrast resulting in glare, the effect of light of different colours on the eye, the relation between inadequate illumination and defects in eyesight, &c.

The presence of the Presidents of the Ophthalmological Society and the Medical Officers in Schools Association, and representatives of the Physiological Society at the Society, illustrates the importance attached to the subject. All expressed their recognition of the need for concerted effort. There are several possible methods of attacking these problems of mutual interest. They may, for example, be solved by the experimental methods available to the physiologist and physicist in the laboratory, supplemented by the professional experience of the ophthalmic expert. In other cases the chief need is for statistical data, and medical officers in schools and factories might be able to ascertain many useful facts from their records of vision, the chief requirement being to correlate these data with corresponding information on the conditions of illumination in schools or factories. In this way the lighting conditions leading to defective vision and eyestrain might be recognised, and a step taken towards arresting much of the deterioration of eyesight that is taking place. The matter is of special importance in view of the interest now being taken in the causation and prevention of blindness which was the subject of enquiry by a recent Departmental Committee. A Standing Advisory Council on matters affecting eyesight, on which the Ophthalmological Society and the Royal Society of Medicine are represented, has now been formed. The question of the relation between illumination and vision would fall within the scope of such a Council, which we observe has power to co-opt additional members to deal with special subjects.

It is gratifying to observe the increasing interest being taken by ophthalmic surgeons and the medical profession generally in matters of illumination, and in recent issues of the *British Journal of Ophthalmology* we note several references to the subject. The Journal is under the supervision of a strong editorial committee, its Chairman being Col. J. Herbert Parsons, a Vice-President and past Chairman of Council of the Illuminating Engineering Society, who has been responsible for a considerable amount of work on the relation of illumination to eyesight. We feel sure that opportunities for initiating further inquiries in this direction will be welcomed both by ophthalmic surgeons and experts in lighting; and the paper by Professor Bayliss has fulfilled a most useful function in indicating some lines of fruitful investigation.

## The Illuminating Engineering Society of Japan.

Last year we drew attention to an interesting event that has occurred since the outbreak of war, the formation of an Illuminating Engineering Society in Japan. The probability of such a development was indicated to the writer in conversations with Dr. Oya, Electrical Engineer to the Imperial Electrotechnical Laboratory of Tokyo, and others shortly before the war. But for the disturbance that the war occasioned, the Society would no doubt have been formed at an earlier date. We have now received copies of the first two numbers of the Transactions of the Society, and we observe with pleasure that the Society has been successfully launched under the Presidency of Mr. G. Yamakawa, and that a number of papers on subjects of technical interest have already been presented. Among the subjects dealt with we note Illuminating Engineering in America, the Life of Incandescent Lamps, Indirect Lighting, the Spherical Photometer, &c., The Transactions are printed mainly in Japanese, amidst which familiar technical terms in English occasionally appear.

One of the volumes before us contains an account of a dinner given in honour of Mr. E. W Rice, President of the American Institute of Electrical Engineers, on November 23rd, 1917. Addresses were delivered by Mr. G. Yamakawa (President of the Illuminating Engineering Society of Japan), Mr. S. Oi, Mr. H. Nagaoka, and others. Mr. Yamakawa referred to the friendly relations established with the United States, which, from its proximity, has naturally been in close touch with developments in Japan. We, in this country, though more distant, share the general interest with which the development of the Japanese Illuminating Engineering Society will be watched in Europe. We feel sure that any opportunity for co-operation between the two Societies will be welcomed.

It is too early as yet to form any conception of the chief line of development of lighting in Japan. Hitherto, we imagine, lamps and fittings introduced from abroad have set the standard, but, with the rapidly expanding manufacture of lamps, shades and glassware in Japan, the adaptation of these appliances to Eastern conditions will require consideration. One would imagine that the tradition of ancient methods of illumination from lanterns and well-screened lamps will exert an influence in favour of soft diffused light rather than the somewhat glaring methods that characterised the introduction of the brighter illuminants in the West. Evidence in this direction is afforded by various Japanese catalogues of lighting fittings that have reached us from time to time.

In the address referred to above Mr. Yamakawa remarked that Japan's *rôle* in Illuminating Engineering had hitherto been to learn from others. No doubt in course of time Japan will develop original methods of treating problems, and will specialise in certain directions that may be of considerable interest to workers in the West. For this reason we hope that the Society will make it a practice to publish the most important papers of interest to British and American readers in English, as well as Japanese.

We may conclude by expressing our interest in the work already being done by the Japanese Illuminating Engineering Society, and our best wishes for its future prosperity.

## Natural Science and Education.

The comprehensive Report issued by the Committee on the Position of Natural Science in the Educational System of Great Britain makes out a strong claim for the improvement of facilities for education in science, at schools, colleges and universities. Instruction in science needs strengthening from top to bottom of the existing educational ladder. Thus, it is recommended that natural science should be included in the general education of all up to the age of 16, that increased attention should be given to the subject in girls' schools, and that facilities for specialisation should be provided between the ages of 16 and 18; that the number of scholarships available should be greatly increased.

We are glad to note that the necessity for a wide view in scientific training at schools is emphasised—that what is needed is not merely to impart facts and principles, but to cultivate the scientific spirit. There is a regrettable tendency to divorce science from the study of literature, and, to avoid this, it is suggested that those specialising in science should continue some literary study, and acquire a reading knowledge of French and German.

The Committee endorse the necessity for scientific knowledge in many posts in the Home and Civil Service, and make the useful suggestion that "an enquiry should be made as to the best methods of securing the services of scientific men for the purpose of the State in permanent posts and otherwise." We agree that such an enquiry is needed.

Finally there is the general recommendation that efforts should be made to increase the flow of capable students to the universities and higher technical institutions with a view to securing a larger supply of trained scientific workers for industrial and other purposes. It is now agreed that before the war the resources of this country in scientifically trained men were below what our commerce and industry really demand. Nevertheless, many colleges, so far from having additional students, are largely denuded of their normal complement, and those who pass through are quickly absorbed into the army. While recognising the inevitable demands for man-power we would plead with the Authorities to allot a reasonable proportion of men in the lower medical grades to be trained for future requirements. Otherwise the country will find itself at the end of the war in a worse position in respect of scientific workers than when it entered it.

One encouraging step that may help to fill this gap is the admirable scheme announced by the Council of the Lord Kitchener Memorial Fund for the endowment of scholarships affording higher education, combined with practical experience for officers and men in the Army and Navy and the sons of deceased and disabled officers and men. Travelling scholarships, facilitating study and research abroad are specially mentioned. The scheme will prove invaluable in the case of educated men leaving the army at the expiration of the war, and we trust that it will be applied at once to those invalided out of the army who are in a position to undertake such studies. Finally, we should like to draw attention to one important means of filling the gaps in the ranks of science—the training of educated women. In many directions women should enjoy training facilities equal to those of men, and we see no reason why the opportunities under the Lord Kitchener scheme should not apply equally to the daughters and young widows of officers, who have the necessary qualifications, to profit by the educational facilities extended to their male relatives.

LEON GASTER.

**TRANSACTIONS**

OF

**The Illuminating Engineering Society.**

(Founded in London, 1909.)

*The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.*

# LIGHT AND VISION:

## THE PHYSIOLOGY OF THE RETINA.

(Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, 18, John St., Adelphi, London, W., at 5 p.m., on Tuesday, April 16th, 1918.)

A MEETING of the Society took place, as stated above, on Tuesday, April 16th, THE PRESIDENT (Mr. A. P. Trotter) in the chair.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the following applicants for membership :—

| | |
|---|---|
| Lt.-Commander A. M. BARNES, R.N.V.R. | H.M.S. Vernon, Portsmouth. |
| G. B. PEARCE .. .. .. | Mech. Engineer, Sydney Grange, Crewe, Cheshire. |
| A. K. TAYLOR .. .. .. | The National Physical Laboratory, Teddington. |

THE PRESIDENT then called upon PROFESSOR W. M. BAYLISS to read his paper entitled **"Light and Vision: The Physiology of the Retina"** (see pp. 104—113).

After dealing in detail with various processes involved in the perception of light by the eye, PROFESSOR BAYLISS mentioned a number of practical lighting problems, into which the physiological element entered and on which fuller information was required, pointing out the desirability of concerted action by lighting experts and oculists in determining the conditions of illumination most agreeable to vision.

In the ensuing discussion the following took part :—MR. E. TREACHER COLLINS (President of the Ophthalmological Society), COL. J. HERBERT PARSONS (the Physiological Society), DR. JAMES KERR (President of the Medical Officers of Schools Association), DR. F. W. EDRIDGE GREEN, LT.-COL. R. H. ELLIOT, MR. J. W. CROWLEY, MR. SAVILLE TAYLOR, MR. R. F. HOWGRAVE GRAHAM, MR. L. GASTER, and THE PRESIDENT.

PROFESSOR W. M. BAYLISS briefly replied to various points raised in the discussion, and a vote of thanks to the lecturer, which was carried with acclamation, terminated the proceedings.

# LIGHT AND VISION:

## THE PHYSIOLOGY OF THE RETINA.

BY W. M. BAYLISS, F.R.S.

(Paper read at a Meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 5 p.m., on Tuesday, April 16th, 1918.)

OUR President, at the end of his annual address, referred briefly to some physiological problems connected with the perception of light. These remarks suggested to me that it might be useful to bring before the Society what is known of the processes which occur in the retina on the incidence of light, in order to find out how far our present knowledge may assist in practical problems of illumination and also to elicit in discussion where further investigation is needed, as it undoubtedly is. It is clear, however, that we must limit the field to some more or less definite questions, if discussion is to be of value.

The phenomena which take place between the incidence of light on the cornea and the mental appreciation of the fact may conveniently be divided into three stages :—

(1) The production of an image on the retina by means of the dioptric system of the eye. This is purely a physical question and has been very completely worked out. The only component of a physiological nature is the mechanism of accommodation, by which the curvature of the lens is changed in order to vary the focal length of the system. It would appear that the muscular mechanism here involved is liable to fatigue and doubtless plays its part in the choice of appropriate methods of illumination, as in the tests used by Ferree.* It will also be plain that insufficient illumination requires more exact and tiring accurate adjustment of focus.

(2) When light arrives at the particular layer of the retina known as that of the rods and cones, it excites a photochemical change of some kind, which, in its turn, acts upon the terminations of the optic nerve fibres and sends along these fibres a series of disturbances, which we call nerve impulses.

(3) Arriving at the brain, these impulses are distributed to a complex system of centres composed of nerve cells, where processes occur associated, in some mysterious way, with the conscious perception of light and illuminated objects.

It is to the processes in the retina itself that we must confine ourselves this afternoon, on account of limits of time.

There are, however, one or two facts which we must recall to mind before proceeding to further details.

I have already mentioned that it is through the optic nerve that the retina sends its messages to the brain. To use the ordinary expression, the fibres of this nerve are stimulated by the changes evoked in the retina by the impact of light energy. We naturally ask the question—what kind of sensation do we experience if the optic nerve is stimulated in other ways, as can be done by means of sufficiently powerful agents? The answer is, that whatever be the way in which the optic nerve is stimulated, the sensation is one of light. This statement applies, altering light for sound, taste, etc., to all the nerves of special sense and is commonly known as Müller's law. In point of fact, it had been formulated by Sir Chas. Bell at an earlier date, though perhaps in not so complete a form. The sensation, then, is an affair of the brain, the "cerebral analysers," as Pavlov calls them, and provided that this part of the brain is set into activity, it matters not by what means, the sensation is the same. This again applies to all the special senses. What then is the function of the elaborate structure at the peripheral end of the nerve? Such organs are known in general as "receptors" and their function may be grasped

* Trans. Illumin. Engineering Soc. (U.S.A.). Vol. VIII. p. 40, and Ferree and Rand., do.

if we try to stimulate the optic nerve by throwing a beam of light upon it. Nothing happens at all, because the nerve fibres are not responsive to light energy. Some sort of mechanism that is affected by this form of energy must be provided and is to be found in the rod and cone layer of the retina. Put in another way, some change great enough to excite the ends of the optic nerve is brought about and the mechanism must be sensitive enough to produce this effect even when the actual energy value of the incident light is very small indeed. How sensitive the retina is may be realised from the experiments of Victor Henri,* who found it to be 3000 times as sensitive as the most rapid photographic plate. We may compare the process in nerves to an electrical current, and all the evidence that we possess indicates that, whatever its nature may be, it is the same in all nerves. What is passing along the optic nerve when a light sensation is experienced is identical with that passing along the auditory nerve when a sound is heard. And, just as we use different kinds of mechanism for converting various forms of energy into electrical currents, telephone for sound, photo-electric cell for light, thermopile for heat, dynamo machine for energy of motion, so we possess different kinds of receptor organs for the perception of these forms of energy.

There is, however, in many of our sense organs, an additional mechanism, analogous to a relay in an electrical circuit. This is for the purpose of increasing the magnitude of the stimulus so that it may be great enough to affect the nerves. It is clear that this requires the provision of an extraneous source of energy derived from chemical oxidations in the living cells of the sense organs.

There is one more fact to be noted. The sun's rays differ physically in wave length only, yet we perceive those of long wave length by the skin and as heat, not light; those of rather shorter length as light by the eye; those of still shorter wave length, the ultra-violet, we do not perceive at all, except occasionally by their indirect chemical effects. The heat spots in the skin are so arranged as only to be affected by the rays of longer wave length, while the retina is only affected by rays of wave length between about 760 and 400 $\mu\mu$.

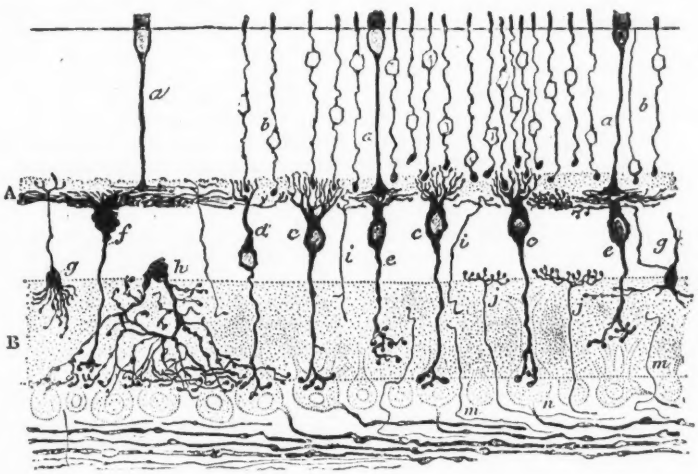


FIG. 1.—Retina of the Eye (Dig), as seen under the microscope. (Ramon Y Cajal).

When we examine under the microscope a section of the retina of one of the higher vertebrates we notice that, in addition to the rod and cone

* Journ. de Physiol. et Pathol. Gén., Vol. XIII., p. 856.

layer, there are other layers consisting of nerve cells. These latter, properly speaking, do not belong to the receptor organ, but are probably of the nature of relays. In the eye of the cuttle-fish, they form a separate mass outside the eye itself. There has been much dispute as to the distinctive functions of the rods and cones. We know that the latter are sensitive to light, because at the point of most distinct vision, the fovea centralis, there are cones only. As we proceed towards the more peripheral regions of the retina, the rods preponderate in number more and more over the cones, but it is not possible to find a place sensitive to light where rods are the only percipient elements. The connection of the rods are, however, so similar to those of the cones as to suggest that they are also receptors for light, although Dr. Edridge-Green holds that their function is limited to the secretion of visual purple. It has also been suggested that the rods are responsible only for a sensation of white and it appears that they play an important part in the phenomena of adaptation to be referred to presently.

Proceeding now to what is of most immediate interest to us, namely, what happens in the retina when light strikes it, we find that a variety of events occur, some of which are without particular significance in our present state of knowledge. The cones themselves are retracted by contraction of their stalks, while the pigment cells send out protrusions which pass between the outer limbs of the rods. The function of the pigment cells is usually held to be the production of visual purple and, if so, the object of their pushing their processes into the rod and cone layer is clear.

The only satisfactory explanation of the mode of stimulation of the retina by light is that it is through the intermediation of a chemical reaction brought about by radiant energy of a limited series of wave lengths. As yet, only one substance sensitive to light has been discovered in this situation. This is usually known as "visual purple," but its actual colour would be described by most people as deep rose red. It can easily be seen in the retina of a frog which has been kept in the dark for a day or two. The frog is killed and the eye dissected out by the light of the sodium flame or the dim red light of a photographic "dark" room. The eyeball is cut across with a razor in a direction perpendicular to the optical axis, and the retinal half is seized with forceps by the sclerotic coat and shaken while immersed in a solution of alum. This separates the retina from the other layers. The dish can then be taken out to the daylight and the pigment remains long enough for its beautiful colour to be seen. It is completely bleached in about half-a-minute. Suppose that we leave the retina in the eyeball without disturbing it, expose to light until bleached and then place in the dark again. What happens? The colour returns and we have again a system sensitive to light.

But what evidence is there that this visual purple has anything to do with vision? Remembering in the first place Grotthus' law, that light can only produce an effect in proportion as it is absorbed, it is of importance to investigate the absorbent properties of visual purple as regards that part of the spectrum which is visible to us. This has been done by Victor Henri and Larguier des Bancels*. They determined the absorption of light by solutions of visual purple, compared it with the degree of chemical action and also with the minimal amount of light energy required to excite a just perceptible sensation from the peripheral parts of the retina. The determinations were made throughout the visible spectrum and the three curves show a remarkable agreement. These facts show that visual purple is at least the most important photochemically sensitive component of the retina, if not the only one. We note also that there are no absorption bands in its spectrum, so that there is no difficulty with respect to colour vision. An interesting fact comes out from the curve of sensibility of the retina compared with the energy of the light acting. At that particular frequency of vibration corresponding to the yellow-green, the threshold of stimulus coincides with the energy quantum of Planck for that rate of vibration. In other words, the retina

* Loc. cit., pp. 841-856.

is sensitive to as small an incidence of energy as it is possible for it to receive.

Practically nothing is known as to the chemical nature of visual purple, on account of the very small amount that it is possible to obtain. It appears to exist in colloidal solution in a liquid in which the rods and cones are immersed. The rods become stained by it, at all events after death. Some difficulty may be felt in the fact that none is produced in the central fovea, where vision is most perfect. Dr. Edridge-Green believes that he has evidence that it flows in from the surrounding parts of the retina.

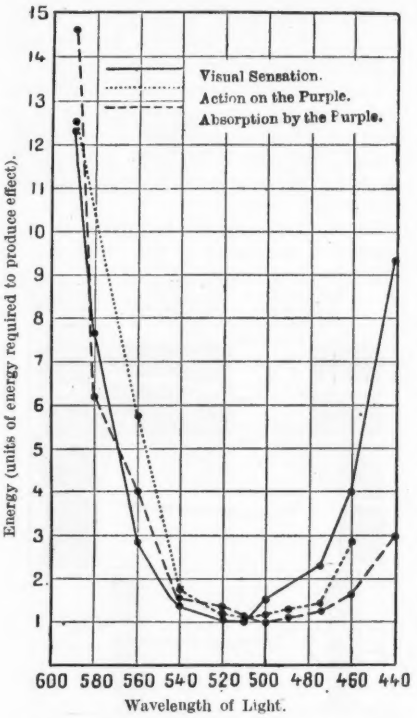


FIG. 2.—Curves illustrating Threshold of Visual Sensation, Action of Light on Visual Purple, and Absorption of Light by Visual Purple. (V. Henri et Larguier des Bancels.)

We have seen then that visual purple is bleached by light and that it reappears in darkness, possibly being formed again from the products of its decomposition. In fact, the kind of photochemical reaction in question seems to be most like that of silver bromide in a closed tube and a comparison of the two reactions is instructive from the point of view of the physiology of the retina. When light falls upon silver bromide it is decomposed into silver and bromine. But, in the absence of a continuous supply of light energy, these products combine again. Accordingly, under the influence of a particular given intensity of illumination, there is a balance of two opposite reactions, resulting in the presence of a certain relative proportion of silver, bromine and silver bromide. But this stationary condition differs from a true chemical equilibrium in a balanced reversible reaction in that it is only maintained as long as external energy continues to be supplied.

Assuming that the chemical change produced by light is the agent that stimulates the ends of the optic nerve fibres, we appreciate the importance of a knowledge of the time course of the reaction. The best information is obtained from records of the electrical changes which accompany the action of light. Comparing those from the vertebrate with that of the Octopus, we are justified in regarding the complexity of the former as due to the presence of the extraneous nerve cells and the simple form of the latter as being the more correct representation of the essential phenomena.

Although we cannot, as yet, pretend to explain all the phenomena of vision on the basis of the facts briefly outlined above, a large number of them can be satisfactorily accounted for.

Notice, firstly, that the curve gradually falls, the stimulus merely disappears, on the advent of darkness. There is no indication of a stimulus of any kind produced by darkness. This is contrary to the well-known theory of Hering, according to which the reaction of restoration, occurring when the light ceases, is associated with a positive sensation of darkness. This point of view had been applied to physiological phenomena in general, but is now practically given up.

Secondly, the curve, after it has attained its maximum, remains constant while the illumination lasts, as we should

expect from the circumstance of the pseudo-equilibrium already referred to.

Thirdly, the reaction does not attain its full intensity suddenly, nor do the products disappear suddenly. In other words, the sensation does not appear at once, nor does it immediately disappear when the stimulus ceases. This is the obvious explanation of the absence of flicker when the alternations of light and darkness are sufficiently rapid. Further, as would be expected from a chemical reaction, the greater its magnitude, the longer it requires for the products to recombine or otherwise disappear. Incidentally, the form of the curve differs somewhat for different colours.

Intervals of 0·1 second.

(*a*) Eye of Pigeon. Brief Illumination (0·23 second). Negative and positive variations with Light, position with subsequent darkness.

(*b*) Eye of Pigeon. Longer period of light (0·72 second).

(*c*) Effect of brief period of darkness (0·1 second) on eye of Pigeon, previously exposed to continuous illumination.

(*d*) Eye of Rabbit. Illumination for 0·5 second. Positive variation. Small, slow, negative variation, after short latent period with subsequent darkness.

(*e*) Eye of Cephalopod. Simple positive reaction with light, after latent period of 0·023 second; remaining practically constant during illumination. Return to original value with darkness, also after a latent period.

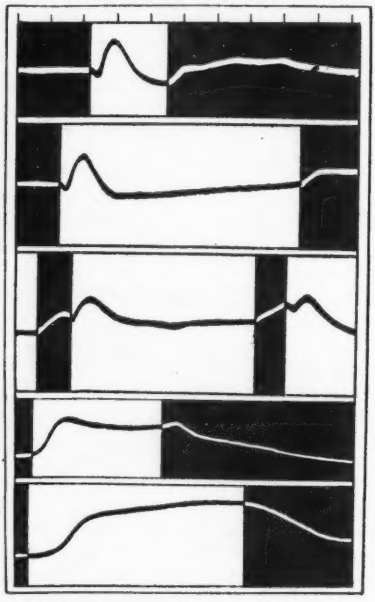


FIG. 3.—Electrical changes produced by Light in the Retina (Einthoven string galvanometer). White areas are periods of illumination, dark areas periods of darkness. (After Piper).

Fourthly, the latent period shown in the figure has its importance with respect to Talbot's law and the use of the rotating sector. Physically, of course, the time integral of illumination is exactly proportional to the area of the open sector. But, is this the case physiologically? Parker and Patten* have shown, by careful experiments, that it is not. The light from one and the same source was reduced to the same physical value, as measured by the radio-micrometer of Boys, in one case by a rotating sector, in the other by a diaphragm. When observed by the eye, the former was 6 per cent. less bright than the latter.

Something similar was found by Bunsen and Roscoe in the action of light on a mixture of hydrogen and chlorine. A period of "photo-chemical induction" elapsed before any detectable change occurred.

There is reason to believe that the maximum sensibility of the fovea is not when it is the only part of the retina illuminated, but when there is simultaneously a weak illumination of the surrounding parts. This seems to be connected in some way with the production and movement of the visual purple. Possibly, the products of the light reaction in the more peripheral parts may diffuse to the more brightly illuminated one, causing the formation of a larger quantity of the photo-sensitive

* Amer. Journ. Physiol., Vol. XXXI. p. 22.

substance. On the other hand, the phenomenon may have its seat in the brain. If it exists, and it seems to be deserving of more investigation, it is clearly of importance in observations with such instruments as the polarimeter and the microscope, as well as in the illumination of the picture palace.

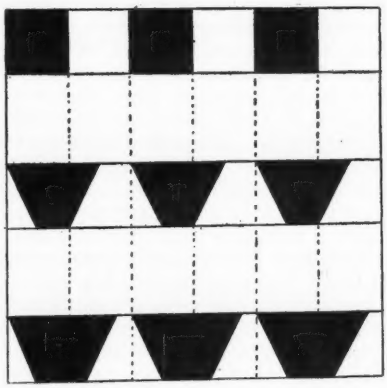

FIG. 4.—Sensation of Light in relation to Periodic Illumination. The two upper diagrams would be in accordance with Talbot's Law and, according to Parker and Patten, are not quite correct. The lowest diagram expresses their results, showing a greater latent period ("induction-period") on incidence of Light than on its cessation.

The explanation of the positive and negative after-images is fairly obvious. The former is accounted for by the results of the photo-chemical change not disappearing at once. The latter is due to temporary exhaustion of the sensitive material by the previous illumination, so that the particular region when stimulated by renewed light is less sensitive than normal. An interesting fact in connection with after-images has been pointed out by Edridge-Green.* That is, that its situation and form can be altered somewhat by jerking the head. This result indicates that the chemical change induced by light is located in the liquid surrounding the rod and cone elements and that these are affected secondarily.

The adaptation of the retina to light and to darkness, by which its sensibility is so greatly changed, is doubtless due to a change in the position of the pseudo-equilibrium referred to previously. This state is of practical importance in relation to sudden changes of illumination. The iris does not react rapidly enough to obviate the injurious effect of the powerful stimulus to a retina of greatly increased sensibility. As I think it was expressed by Mr. Trotter, the iris really takes advantage of the brilliant illumination in order to diminish spherical aberration, while at the same time it serves to decrease the stimulus to the retina.

In the latter part of this paper I should like to refer briefly to a few questions that have been raised in previous discussions of the Society and brought before my notice by your Hon. Secretary. These are no doubt the problems which your President had in mind when, in his Address, he expressed the desire for further study of illumination at the hands of physiologists.

It is only just to point out that many of these problems are of a very complex and difficult nature, and that the physiologist, who has to deal with the mechanism of the eye, affected as it is by so many different external factors as well as the inherent predispositions of different persons, has a very much more difficult task than ordinarily falls to the lot of the illuminating engineer. Most of these problems require further investigation, and I hope that the discussion will suggest some useful paths of inquiry.

Such problems involve the co-operation of several classes of experts. The physiologist can bring to bear his experience of the mechanism of the eye, reinforced by experiments in his laboratory; the ophthalmic surgeon and the oculist could no doubt furnish useful information from their consulting experience; while there are others, such as medical officers in schools, and physicians concerned with the inspection of factory workers, who are in a favourable position to accumulate data as to the effect of varied conditions of illumination.

I will deal first with several points which fall within the scope of the physiologist. I understand that the study of photometry and of vision by weak illuminations has led illuminating engineers to take an interest in the various

* Journ. of Physiol., Vol. XLV., p. 70.

theories of retinal action that have been put forward to explain such phenomena as the so-called "night-blindness," the changes in the appearance of colours by faint light, and the fact that at low illuminations the centre of the retina, the fovea, becomes practically insensible to light. While these facts are not disputed, and a knowledge of them is of considerable importance to anyone interested in problems involving vision by night, the relative functions of the rods and the cones are still in dispute and the decision is clearly one of great difficulty.

I come next to the question of glare and contrast to which great importance has rightly been attached by the Society from the commencement of its work, and which was dealt with in some detail in a paper by Dr. James Kerr before the Society last year.* From the physiological standpoint there can be no doubt that the contrast should not be too great owing to the unpleasant and injurious effect of a sudden illumination of a spot on the retina rendered sensitive by previous comparative darkness. Any very intense stimulation of a nerve of special sense is more or less painful, and therefore injurious, since pain is as a rule a protective warning. It is difficult to state exactly what occurs on the retina when the unpleasant sensation resulting from exposure of the eye to excessive contrasts is experienced; but it is a fact that when very intense and prolonged exposure takes place detectable damage to the cell structures can be made out. The presumption is that any glaring conditions which cause discomfort are prejudicial. In mild cases of glare the discomfort is only temporary and the great recuperative power of the eye may prevent appreciable injury. But it might well be that if the eye was habitually subjected to glare this would have the effect of hastening failing sight in later years, even though no apparent ill-effects were experienced at the time. The difficulty of imposing definite limits to glare arises (1) from the varying resisting and recuperative powers of different eyes, and (2) from the fact that the eye, at any moment, is affected differently by a light of given brightness according to its state of adaptation. The effect of adaptation in altering the "glare-limit" was brought out in some interesting experiments by Mr. P. G. Nutting,* who measured the brightness of a small area when made just painful to the eye in different states of adaptation. Mr. Nutting's experiments afford some support for the suggestion that the ratio of brightness of objects in the field of view should not exceed 100 : 1. While it would be premature to say that a physiological basis for this suggestion is established, it seems a reasonable figure to take, and there seems every reason to support the general principle, on which illuminating engineers lay stress, that no unshaded bright sources, such as filaments or incandescent mantles, should be allowed to fall within the direct range of vision.

The one position where, if anywhere, such bright sources are permissible (so far as glare is concerned) is immediately overhead. It has been suggested that the vertical angle between the direction of vision and a line joining the eye to the unshaded source should not be less than 60 degrees. In these circumstances the eye is shielded by the brow and upper eyelid, in a manner possibly contrived by Nature as a protection from the sun's rays. The corresponding protection from direct rays reaching the eye from below is much less perfect, and therefore glare in the form of reflected light from polished surfaces of desks, highly calendered paper, etc., is apt to be distressing.

As regards the effect of a bright object towards the periphery of the retina, which is seen "out of the tail of the eye" the effect may be, if anything, more distressing than when focussed on the central part of the retina, especially when the eye is in a dark-adapted state. The effect of such lateral illumination has been fully discussed by Mr. J. Herbert Parsons, in an Appendix to the Report of the Departmental (Home Office) Committee on Lighting in Factories and Workshops. This contribution gives a good idea of the complexity of the phenomena underlying vision. According to some authorities the unpleasant feeling

* Illumin. Engineer, Feb., 1917.

* Illumin. Engineer, March and April, 1917.

of dazzling, and the disturbance of vision caused by dazzling are different things. While the presence of a bright source of light in the field of view will in general prove distracting and produce discomfort, it does not invariably diminish acuteness of vision ; in some cases it may even temporarily increase it, although one would presume at the expense of a certain strain on the eye.

While dealing with this question of contrast I may refer to another debatable point—the relative merits of the so-called general diffused illumination, and local concentration of light. Here again I do not think that I can adduce direct physiological evidence, but I consider conditions of moderate contrast, a *via media* between sharp contrasts and monotony of effect desirable. I have been asked, for example, whether a limit on physiological grounds could be given for the relative brightness of walls and ceiling, or between the illumination on the work and surroundings. It is possible that, as has been suggested, it may be a relief to the eye for the gaze to be occasionally transferred from a bright area to one of subdued brilliancy, but the contrast should not be too sudden, and ought probably not to exceed the ratio of 100 : 1 suggested above.

Here the time element also comes in. Dr. Kerr emphasised in his paper the trying effect of rapid fluctuations in brightness, such as may occur in cinema theatres, etc. A parallel case is the experience of a worker whose eye is constantly roving over several machines receiving local illumination, and therefore experiencing rapid fluctuations in brightness. It seems reasonable to suggest that in such cases the illumination should diminish gradually on either side of the work, and that the adjacent area for a certain distance on either side of it should receive some illumination. In fact local illumination of this kind ought to be supplemented by moderate general illumination.

Yet another problem is the effect of colour. Is it possible to state that light of certain colours is more agreeable or less fatiguing to the eye than others ? To justify for example the preference often expressed for the mellow yellow light of the oil lamp ? While prolonged exposure to light of certain wave-lengths only might conceivably be prejudicial to the eye, or have a disturbing effect on colour vision, there hardly seems at present sufficient evidence to dogmatise on this point. Researches in the United States have indicated that the greatest acuteness of vision might be obtained with mono-chromatic yellow light, and it is well known that for microscope work monochromatic light is preferred, though this is probably partly due to the fact that the resolution of instrument in these circumstances is greater. This claim for greater acuteness of vision seems to be based on the want of achromatism of the eye, and this is essentially a different question from fatigue. It is interesting to note that according to Ferree's observations apparently the yellow light of an oil lamp or the blue of a " true tint " electric incandescent lamp were more fatiguing than the nearly white light of a half-watt lamp. It appears as if any coloured light might be considered inferior to white in the aspect considered, but it is difficult to suggest physiological grounds.

The next point I have been asked is whether it is possible to contrive a general test of eye-fatigue, such as could be applied to demonstrate the effect of different systems of illumination, or to indicate whether the illumination is adequate for the work ? Here you meet in an acute form the difficulties of the physiological side of the illumination. Various conditions are classed under the heading of eye-strain. General bodily fatigue reacts upon the eyes, and the same is true of ill-health. Conversely a continual strain on the eyes might in some cases not reveal itself by deterioration of that organ, but by headache, or other symptoms of general physical discomfort. Again, assuming that one has evolved a satisfactory test of eye-fatigue, one has the further problem of separating the fatigue due to defective illumination from that arising from overwork, and similar extraneous factors.

I mention these points to show that a very careful investigation is needed before one could come to a definite decision. A considerable amount of work has been done on the subject of fatigue, for example in the researches carried out by Dr. Stanley Kent for the

Health of Munition Workers' Committee. Tests of fatigue included examination of vision and power of hearing, ergograph tests, response to stimulus, etc. Such tests afford indications of the existence of fatigue, and it is possible that their application in conjunction with correlated studies of the lighting conditions under which work is done would afford useful information. My attention has also been drawn to the investigations of Ferree (*loc. cit.*) who studied the effect of different systems of lighting by making the person experimented upon observe an object for a given period, and noted the time during which it appeared respectively "clear" and "blurred." This test, so far as I can see, indicates fatigue of the muscular adjustments of the eye in accommodation, convergence and fixation. In this way Ferree claims to have exhibited the influence of an unduly glaring light. It would however seem desirable to approach the problem from several different standpoints before coming to a decision regarding any particular system of lighting.

Finally, I come to another department of investigation, which may be termed the statistical. Mr. Gaster, in his address in January last, pointed out the desirability of obtaining fuller data on the effect of illumination on eyesight, especially with reference to children in schools and workers in factories. Among questions which it is desirable to answer are the following: What is the effect on the vision of (*a*) normal school-children, and (*b*) children with imperfect vision, of working by unsatisfactory illumination? What statistics are available to show what proportion of faulty eyesight can be attributed to unsatisfactory lighting conditions? What data can be adduced to show the effect of inadequate illumination on the vision of workers in various trades?

This opens up another line of investigation, namely, the preparation of concrete evidence of the results of working by insufficient light.

In regard to factories it has been pointed out that the present exceptional circumstances are favourable to such investigation. A very large number of factories are under Government control, the processes and hours of work are similar, and the health of the workers is being made the subject of special study. It should not be impracticable to include in these inquiries some investigation of lighting conditions in relation to vision.

Again most authorities would agree that insufficient lighting in schoolrooms, by encouraging the habit of close reading would be favourable to the development of myopia in school-children, that children who are already myopic and astigmatic, and for whom special classes are now suggested, are specially liable to suffer from defective lighting conditions, and that such conditions, apart from their immediate effect on the eyes, add to the strain of work. None of us will underestimate the importance of this problem. The State, which is becoming more and more the guardian of national education, and is assumed to care for their eyesight and to provide glasses, should therefore be equally concerned with the provision of adequate illumination, both natural and artificial, in order to ensure that their studies are pursued without prejudice to their eyesight. Before the war a Joint Committee of this Society drafted a series of simple recommendations on school lighting which deserve to be widely known to educational authorities. If these recommendations could be supplemented by detailed experience of the disadvantages of inadequate lighting it would no doubt be of great assistance to the objects which the Society has in view, and such bodies as the Medical Officers of Schools' Association would no doubt be able to give material help in the collection of information.

Nor should it be forgotten that the process of education continues to some extent at home. Parents should be cautioned against allowing children to do their home work by inadequate light, and even in these times, if economy in lighting in the home must be exercised, it should not be allowed to prejudice the provision of proper illumination for the children's study.

Finally there is the very wide question of the influence of conditions of illumination, both natural and artificial, on the

eyesight of the nation in general, as a factor in the causation of blindness. It goes without saying that any deficiences in illumination that impose a strain on the eye may have a cumulative prejudicial effect, especially if a predisposition to weakness exists. I concur with the suggestion that an investigation into this point might lead to some very useful information being acquired.

## *DISCUSSION.*

Mr. E. TREACHER COLLINS (President of the Ophthalmological Society) endorsed the statements of the lecturer regarding the need for co-operation between illuminating engineers, physiologists, ophthalmic surgeons, physicists, and medical officers of schools and factories, in order to clear up debateable points in connection with the effect of illumination on vision.

As Professor Bayliss had remarked the problem of establishing a general test of eye-fatigue was a difficult one, and its complexity would, he thought, be better realised if he enumerated the many different factors which caused variation in individuals of susceptibility to light. First there was the prominence of the eyes in the orbit and the character of the eyebrows. Deep set eyes with bushy eyebrows were more protected than prominent ones with scanty eyebrows from top lights. The length and colour of the eyelashes was another material factor. Those races of men who had for generations inhabited glary districts, for example the Arab and Turkoman races, were generally noted for the length and darkness of their eyelashes. He had had personal experience of the effect of pigment on the skin of the lids. When touring in glary districts he had found great relief was afforded by smearing a little charcoal over the eyelids. Dark races had such a natural protection in the pigment of their skin. Whereas Europeans, when touring in tropical districts, had to protect themselves with broad-brimmed hats, most of the natives of such districts did not.

Then again the amount of pigment in the uveal tract and retinal epithelium had a considerable influence on sensibility. Albinos were always photophobic. The condition of the media in the eye through which the light passed to the retina was another factor influencing sensibility to light. Patients who had a cataract removed from the eye were liable, on exposure to glare, to get what was known as "red vision" ("erythopsia"); apparently the lens cut off certain rays of light which, when it was absent, passed in and gave rise to this condition. Red-vision was also sometimes met with in school children though the cause was not accurately known. As age advanced the lens became harder and red-vision was less liable to occur. Dilatation of the pupil exposed the eye more to the effects of glare than when it was contracted. The condition of the general health had an influence on sensitiveness to light. The condition known as "night-blindness" occurred chiefly in ill-nourished people and was best accounted for by regarding it as due to complete exhaustion of the visual purple, and the consequent deprivation of "rod-vision" as distinguishd from "cone-vision." We all experienced this condition temporarily after reading for a while out of doors in the sunlight, the reflected light from the book completely bleached the visual purple. We felt dazed and on going into a dark room were unable to see for a time.

Occupations where the eye was exposed to excessive reflected light from glistening surfaces such as were met with in munition works produced a similar condition. It was possible to have too much light in factories.

Some people were undoubtedly more sensitive to light than others, due to the condition of their nervous system just as some people were more sensitive to pain than others. Imagination might have a potent effect upon the eyes. He had met with patients who came to him with dark glasses and shades over their eyes and said they could not stand the light, who after he had talked to them for a while removed their glasses, would go away without such protection and with their eyes wide open.

The effect of colour on the mind was

also interesting. A manufacturer of photographic films told him that his employees, when working in a room, lighted with red light, complained that the room was too hot. He took the temperatures, turned them out, and then substituted a blue light. On their return they said that the room was much cooler, whereas the temperature was in reality the same.

Col. J. HERBERT PARSONS, representing the Physiological Society, said that the paper had served to illustrate the extreme complexity of the subject, and the many opportunities for further research. The author had done good services in bringing before the Society some of the physiological aspects of illumination, with which physicists were not generally familiar.

The series of curves shown by the lecturer illustrated the close relation between the perception of light and the visual purple. He would like to add to these two other curves, which were practically identical with those shown by the author, namely the luminosity or brightness curve of the acaptopic eye, *i.e.*, the eye adapted for light of low intensity, and the luminosity curve of the totally colour-blind eye. The identity of these curves was really a most extraordinary phenomenon.

He wished that Professor Bayliss would some day read a lecture on the relationship between adaptation and fatigue. Physicists were apt to speak of the fatigue of the retina, when the effect they were really referring to was adaptation. Sir William Abney, for example, among others had used the word in this sense. In reality the two phenomena were quite distinct, although in some cases it was difficult to draw a sharp line between the two. For example, if a portion of the retina was "fatigued" for light of a particular wave length and exposed to the complementary colour, the sensation produced far exceeded in brilliancy the sensation produced without previous stimulation.

He would like to draw attention to one fact, namely, that there had not been, he believed, any previous meeting of the Society at which so many ophthalmologists were present. That in itself betokened a growing interest in the relation of physiology to lighting problems—an interest which was very largely due to the enthusiasm and pertinacity of the Hon. Secretary, Mr. Gaster. He was always bringing forward new problems for discussion and he hoped that he would be successful in inducing physiologists and ophthalmologists to apply themselves to these practical points in connection with lighting.

Dr. F. W. EDRIDGE GREEN said that he would confine himself to one point, namely, the functions of the rods and cones. He considered that no evidence had ever been presented which justified the theory that the rods were percipient elements. Curves had been presented which fitted in with the conception of the part played by the visual purple, and evolved from physical and dynamical laws. They illustrated the fundamental properties of any photo-chemical substance. Overwhelming evidence pointed to the conclusion that the cones were the sole percipient elements and the visual purple the visual substance, its distribution being controlled by the rods. Decomposition of the visual purple by light stimulated the cones and visual impulses were formed. The visual purple when the retina was examined microscopically could be seen between the cones in the fovea, having diffused there from the surrounding parts of the retina.

The centre of the fovea might be at one moment insensitive to light and then the most sensitive part of the whole retina. Holmholtz had mentioned this fact but had no conception of the internal process. On waking up in the morning one could recognise the foveal region by the appearance of a black spot on the ceiling. If one put one's head under the clothes one next saw purple circles, corresponding to the circulation of the visual purple which was all the time going on in the retina. These circles became brighter until, when they reached the fovea, they broke up into star-shaped figure. The moment that happened when one pulled down the clothes and looked at the ceiling one saw an absolutely dazzling spot. If one waited until the circle broke up and dispersed there was the black spot on the ceiling as before. This simple experiment

proved that the fovea was sensitised from the periphery.

Dr. JAMES KERR (President of the Medical Officers of Schools Association) said that adaptation was a process of fundamental importance which entered into almost every observation in which the illuminating engineer was concerned. In dealing with the subject of glare he had pointed out that the limiting brightness which became " glaring " was continually varying according to the state of adaptation of the eye. He was therefore glad to see that the author had emphasised the desirability of limiting the contrasts in brightness in artificial lighting, rather than imposing a fixed standard of what could be considered glaring.

Adaptation had also a great deal to do with the standard of illumination necessary in different circumstances. If the surroundings were unduly bright the illumination on the work had to be " keyed up " to a corresponding value. But if there were no exposed brilliant spots of light present the eye would be able to utilise a lower illumination than would otherwise be necessary. One met very striking instances of this in dealing with daylight illumination. The presence of the bright sky above, or of light streaming in through windows, made all objects of relatively low brightness obscure, even though they received an amount of illumination which would be considered extremely high in artificial lighting. He had noticed for example that children in schools, who had worked quite well at desks in the school with an illumination of one or two foot-candles, often complained of the darkness of playsheds receiving daylight illumination of many times this value.

Many of the scientific points alluded to in the paper were of great practical importance and the Society was doing extremely valuable work in presenting these problems in a definite form, and endeavouring to promote the co-operation necessary for their solution. He could not help feeling that in this country we had not yet succeeded in using our intellectual resources to the fullest extent. There were plenty of brains available, but inadequate machinery for setting them in motion. Our general education did not give the man in the street a scientific method and outlook. The Illuminating Engineering Society, by acting as a link between the lighting engineer and the physiologist, was helping to bring about the kind of co-operation that was needed.

Lt.-Col. R. H. ELLIOTT said that he was very much interested in the subject from the point of view of having lived many years in the tropics and seen a great deal of photo-phobia from glare. The effect of this on the human system was extraordinary. He remembered the case of a missionary whose one object was to get out of the country. He abandoned his missionary work, his only object being to get away. Another instance was that of a man who had been assured by a doctor there was nothing serious wrong with him. The effect on him was such that he went back to his estate in Ceylon and drowned himself.

The effect of glare upon people, especially in sunny and snow-bound countries was very remarkable. One would have thought that the light-skinned man with blue eyes and light hair would have been the most to suffer. He had been out all day shooting with such men in the tropics and they did not feel the glare at all; whereas on the other hand many dark-skinned and dark-eyed natives had broken down through glare. Therefore there was obviously something more than merely an effect upon the retina, and he ventured to think it was to be found in the effect of the ultra-violet rays on the living membrane of the eye or conjunctive. He himself had been treated for this and had since been able to help other people. The effect of the ultra-violet light produced a mild form of conjunctivitis which could be cured.

Mr. TREACHER COLLINS agreed that ultra-violet light affected the surface of the eye and not the interior.

Lt.-Col. ELLIOTT added that workers with X-rays also often suffered from a form of inflammation of the conjunctiva and suffered greatly from glare.

Dr. J. F. CROWLEY, referring to the caution which was uttered in the paper as to allowing children to do home work, said that in Germany, just previously to the war, he noticed that some firms, in connection with the movement for improving the condition of their employees, actually provided schoolrooms under adequate supervision where children could do their home work. Although the houses of the German workmen were much superior to the usual houses of many of our workpeople in this country, he was told that the lighting in such private houses was particularly bad. Accordingly, the special schoolrooms were provided for the children.

Would the author kindly explain how the electrical curves he had shown were taken? He understood him to say that they involved the use of the Einthoven galvanometer.

Mr. SAVILLE TAYLOR said that he had much enjoyed the paper and the discussion. It should be the task of the illuminating engineer to provide the conditions which were most comfortable to the eye. The sense of colour had a powerful effect, for example, it might overcome hunger in the sense that food served up in a manner unappetising to the eye, might not be acceptable even to a hungry man. It was curious that while the eye objected to glare it was relatively poorly equipped with means of protection against it. It was therefore the duty of lighting experts to eliminate glare in artificial light, which was so completely under human control, even though it might not be possible to do so in the case of natural light.

Mr. R. P. HOWGRAVE GRAHAM said that the subject under discussion was one of great consequence to the illuminating engineer, and the Society was to be congratulated on bringing in contact physiologists and experts in lighting, so that both the engineering and physiological aspects of the illumination could be considered.

The PRESIDENT said that he claimed some little credit for the interesting paper to which they had listened because, as the author had mentioned, he himself had referred to some physiological problems in his Presidential Address and had asked for such a paper as this. The particular one to which he had referred was the sensitiveness of the eye over the enormous range of illumination from the dazzling lights where of course the sensitiveness began to fall off down to feeble illuminations, and it was very interesting to hear that the minimum had a relationship to the physical minimum quantum of energy.

He had read about that quantum of energy but had no idea that anybody had arrived at it physically, much less physiologically. It appeared from the paper that the eye could begin to measure at the very smallest degree of illumination and that it had its measuring power intact up to very high illuminations. He supposed that we must take it, as the author suggested, that after all this was merely a matter of the relation of the chemical decomposition to the action of light on the one hand and to the stimulation of the optic nerve on the other. It was difficult to imagine that any nervous control could play this part.

The author spoke of Victor Henri's experiments which found the eye to be 3000 times as sensitive as the most rapid photographic plate. That was rather a difficult comparison because the time element did not come in with the eye. The beautiful results that astronomers had produced with photographic plates were due to hours and hours of exposure and they then saw something which the human eye would never see. He would like to ask how, excluding the time, it was possible to make such a comparison. He would also like to know the time scale of the diagram shown.

He would like to refer to a paper by Dr. Hyde on Talbot's Law as applied to the rotating sector, in the Bulletin of the Bureau of Standards (Vol. II. No. 1, 1906). That paper struck him as being the very high water mark of photometry. He had never seen any work on photometry which impressed him so much with experimental and observational precision. The deviation from Talbot's Law was found not to exceed 0.4 per cent. It seemed to him that Dr. Hyde had settled the matter once and for all as regards the doubts that had been thrown on the Talbot disc. It would be interest-

ing to compare this work with that of Messrs. Parker and Patten.

A question that had been insufficiently studied in connection with the contraction of the iris was the range over which the eye could discriminate differences of tone. He was not aware of any recent work upon this subject. The maximum diameter of the pupil was, he believed, about 0.32 inch (8 mm.). There was a connection between this and the war, for the eye-point of a night-telescope should have a relation to the diameter of the pupil. When a novelist writes that her villain's eyes contracted in his rage to pin-points, she indicates a diameter of about 0·075 inch (say 2 mm.). The difference is about 18 times.

With regard to the comfortable yellow of the oil lamp he had been experimenting with blue daylight lamps and he had sometimes left one burning by mistake. People had said "What a horribly chilly light" it was, and certainly it was distinctly chilly and comfortless compared with the yellow light notwithstanding that it was nearly the true daylight of a July afternoon. He proposed a hearty vote of thanks to the author.

Mr. L. GASTER, in seconding the vote of thanks to the lecturer, said that the paper had served to show how complex were the processes involved in the perception of light, and how useful it was to the lighting expert to have some conception of the structure and requirements of the eye. From its very commencement the Society had appreciated the need for the co-operation of the physiologist and the lighting engineer in studying illumination, and he believed that in the future concerted action would prove to be absolutely essential in dealing with many problems that would arise. Professor Bayliss had mentioned several instances of problems where the medical officer and physiologist could supply valuable confirmatory information. Other instances were to be found in the Interim Report of the Departmental Committee on Lighting in Factories and Workshops, on which Col. Parsons rendered most useful service. Illuminating engineering had now reached a stage when it was becoming desirable to adopt definite requirements in illumination for specific purposes, and the evidence of physiologists in regard to the prejudicial effect of inadequate illumination on health and vision would prove to be an essential element in the determination of such quantities.

Mr. W. C. CLINTON (*communicated*).—I am much obliged for the copy of Dr. Bayliss's most interesting and suggestive paper. Coming from one who can speak with such authority on this subject it will constitute a valuable addition to the records of our Society.

There are one or two questions that I should like to put to the author for his consideration :—

(*a*) I observe that he compares the process of the conveyance of a stimulus in nerves to an electric current. Is it actually a current that flows along nerves when stimulated, that is, is there a transference of electrons along the nerve or not? If the impulse is conveyed to the brain by means of an electric current there must be an electromotive force generated by the applied stimulus, which is, in the case of the eye, the action of light. This suggests that the rods and cones may act as electrodes in some sort of cell of which the fluid is the visual purple, made more or less conducting by the action of light.

(*b*) Can any further information be given on the nature of the "relay" action occurring between the visual purple and the ends of the branches of the optic nerve? If it is an electric current that is first produced, that current can release energy into another circuit only by its magnetic, thermal or chemical action. The first two methods would probably be inadmissible, so that we are confined to speculation as to the kind of chemical action that is possible. Can an electric current go through the walls of a cell without rupturing them? If it can, then the nature of these cells might be such that the passage of a small fraction of a micro-ampère would start a chemical change in them that would go on independently of the starting current, and might conceivably liberate a relatively large amount of energy, perhaps directly as heat, to give the required stimulus to the nerve ends.

Mr. J. S. Dow (*communicated*).—Professor Bayliss has shown how the chemical changes caused by the impact of light on the retina serve to explain many phenomena of vision, such as the sensation of flicker. In experiments on this point some years ago I was struck by the difference in the *quality of flicker* as observed when the light-image is received on the fovea and on the periphery of the retina. In the former case as soon as the speed of a rotating sector disc is sufficient to cause flicker, the sensation is of a fine trembling character which ultimately disappears with increasing speed; but all low illumination, and on the peripheral regions of the retina, the flicker is of a peculiarly coarse violent kind, which cannot be seen by direct vision but only out of the tail of the eye. How is this difference to be explained? I have heard explanations based on theories of the functions of the rods and cones, but I understand that such explanations can no longer be accepted.

In regard to the effect of ultra-violet light on the eye and its possible influence in causing cataract, etc., it is interesting to recall that W. E. Burge* found that the presence in the protein substances in the eye of certain salts, calcium magnesium and sodium silicates, in amounts greatly beyond the normal was an important factor. This suggests that the production of cataract by ultra-violet radiation may occur chiefly where unhealthy organic predisposing conditions exist. This may explain why exposure to severe radiation causes cataract in some cases but not in others.

Professor W. M. BAYLISS (in reply): The remarks of Mr. Treacher Collins on the advantage of pigmented eyelids in brilliant light are of much interest. I suppose that a certain amount of red light always passes through the thickness of the eyelids when closed, and it may be that, when this exceeds a certain low intensity, the impossibility of obtaining rest by closing the eyes becomes a source of much discomfort.

The question of "warm" and "cold" colours is a curiously difficult one. It can scarcely have any connection with the colour of sunlight, since the "cold" electric arc has a yellowish colour in daylight. It would be interesting to know whether the sight of different colours has a vaso-motor reflex as a result. It is conceivable that a red colour might be associated with a dilatation of the blood vessels in the skin and thus give rise to a real sensation of heat.

I would thank Col. Parsons for pointing out the two other curves, the luminosity curve for the eye adopted to low intensity and that for the totally colour-blind, which agree with the curves of visual purple in Fig. 2. They afford further confirmation of the fundamental importance of this substance in the photochemical system of the retina. The relation of "fatigue" and adoptation undoubtedly deserves more investigation.

Although I am prepared to accept Dr. Edridge-Green's view that the visual purple diffuses into the fovea, I have to confess that I am not adept at experiments on entoptic phenomena and have not been able to convince myself of the existence of all the phenomena described by him. As to the functions of the rods, it is difficult to understand their complex nervous connections if they are not percipient elements.

In reference to the remarks of Lt.-Col. Elliott on the effect of ultra-violet light in relation to glare, it seems extremely likely that the discomfort of glare may turn out to be partly due to this effect on the conjunctiva, although there must also be one on the retina itself.

Dr. Crowley asks how the photographs of the electrical change in the retina were obtained. One electrode was placed on the cornea, the other at the opposite pole of the eyeball, so that the retina was led off from anterior and posterior surfaces. The electrodes were connected one to each end of the fine wire of the Einthoven galvanometer and the lines in the figures are the records of the shadow of the wire as it moves between the poles of the electro-magnet.

The President thinks that Victor Henri's comparison of the sensitiveness of the retina and of a photographic plate is not quite a fair one. I agree. I take it that the comparison was only meant to apply to brief illumination. The retina appears to be arranged so as to respond

* Elec. World, April 10th, 1915.

at once with its maximal effect and the intensity of the sensation does not continue to increase with the duration of the illumination. In fact, it would introduce many difficulties if it did so increase.

As to Talbot's law, the President's satisfaction with the experiments of Dr. Hyde is a powerful support of their value. It is possible that an unsuspected source of error may have been present in Parker and Patten's experiments, and it is desirable that they should be repeated.

The calculations of the possible range of differences of intensity available by contraction of the iris shows how impossible it is to explain the capabilities of this eye in this respect by iris action alone.

To discuss in any satisfactory way the questions put by my colleague, Mr. Clinton, would take much space. Although a change of electrical potential is known to pass as a wave along a nerve when a stimulus is applied at a point, the velocity of propagation seems to exclude its being due to a stream of electrons. There is evidence that it is an electrolytic change, associated with concentration of ions at a polarizable membrane, as originally suggested by Nernst. The electro-motive force can be produced in nerve by any kind of stimulus, but, of course, an appreciable, though minute, expenditure of energy is necessary. Whether the action of light is to stimulate the optic nerve through the electrical effects of the photo-chemical change, and whether these electrical effects are, so to speak, accidental, is yet uncertain. I am not sure whether any change of resistance has been detected in the retina.

The " relay " action to which I referred occurs when a new nerve cell comes into the circuit. A nerve cell is a reservoir of potential energy, which can be put into the circuit to enable resistances to be overcome. An electric current can pass through the walls of a cell without doing any harm, and what is of interest is that when the cell has a membrane on its surface permeable to ions of one sign only, as appears to be the case, a current can pass in one direction only. The cell is an electrolytic rectifier. We have in living tissues all the possibilities of electrolytic conduction, in combination with membranes of various kinds of permeability and thus capable of polarization.

The difference between flicker on the fovea and on the peripheral parts of the retina, noticed by Mr. Dow, suggests a difference between the time course of the photo-chemical change in the two situations. Again, we need more investigation.

It is well known that proteins are not easily coagulated in the absence of electrolytes. Egg white, diclyzed free from salts, does not coagulate on boiling. Bivalent ions, or those of higher valency, are much more effective than univalent ions. Ultra-violet light coagulates proteins and would no doubt be more effective in the presence of calcium or magnesium. Hence the view suggested with regard to cataract seems a reasonable one.

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## INDUSTRIAL RECONSTRUCTION COUNCIL.

A Report has been issued summarising the work of the Industrial Reconstruction Council for the three months ending March 31st, 1918. It is recalled that the I.R.C. had its origin in October, 1917, the first public meeting being held at the Guildhall on February 15th in the present year. Meetings have since been addressed in Bristol, Manchester, Nottingham and Edinburgh, and a visit was arranged for Birmingham in May. The I.R.C. has also supplied speakers for the purpose of addressing other organisations, among whom Mr. Ernest J. P. Benn, Dr. William Garnett, Major Sydney Pascall, Mr. Emil Davies and Mr. Frank Elliott are specially mentioned. The Ministers of Reconstruction and Labour have also delivered addresses and the Rt. Hon. J. H. Whitley has expressed his satisfaction with the work being done on behalf of the Whitley Report. The establishment of branch organisations is now being considered.

## MINISTRY OF MUNITIONS.

### Amending the Glass Control (Consolidated) Order, 1917.

According to an announcement issued by the Press Bureau, the Ministry of Munitions is extending the provisions relating to electric lamp glass contained in the Order specified above, to Vitrite and other glass intended to be used for electric lamp caps for insulating purposes.

It is accordingly ordered :—

(1) As from the date hereof of the Glass Control (Consolidated) Order, 1917, shall be read and take effect as if in Clause 8 of that Order the words " and the expression ' electric lamp glass ' shall include all glass used or intended for use in the manufacture of electric lamps, not excepting Vitrite or other glass used or intended for use in electric lamp caps for insulating purposes, but shall not include glass shades and similar accessories " were substituted for the words " and the expression ' electric lamp glass ' shall include all glass used or intended for use in the manufacture of electric lamps, except glass used or intended for use in lamp caps for insulating purposes, but shall not include glass shades and similar accessories."

(2) All applications in reference to the above Order should be made to the Controller of Glassware Supply, Ministry of Mnuitions of War, 22—23, Hertford Street, London, W. 1.

(3) This Order may be cited as the Glass Control (Consolidated) Amendment Order, 1918.

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## MACHINE TOOLS.

Power-driven machine tools or woodworking machines and treadle lathes for woodworking or metal (3-in centres and over) come under the Defence of the Realm Regulation No./30A. Intending purchasers must make application for permission to purchase the machines they require to the Executive Officer of the Area Clearing Board in their district. Firms should apply to the Controller of Machine Tools, Charing Cross Buildings, Embankment, W.C. 2.

It is also announced that new regulations with regard to priority classification in respect of small tools have been issued. Forms of priority Classification Certificates can be obtained at the principal post offices. Small tools must in future form part of a direct Government contract, or authorisation in writing from the Director of Small Tools (address as above) must be obtained in writing.

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## TECHNICAL JOURNALISTS AND TRADE.

The value of the services of trade and technical journalists in connection with the organisation of trade was strongly emphasised at a Conference of Trade and Technical Journalists called by the Scientific, Technical, and Trade Circle of the Institute of Journalists, held at the Stationers' Hall on April 29th.

An instructive paper was read by Mr. S. J. Sewell on " Past and Future Trade," in which a comprehensive series of statistical data, referring to the development of British trade in the period 1869—1913 was presented.

An interesting address was then delivered by Mr. J. L. Garvin, President of the Institute, who occupied the chair. Mr. Garvin referred to many of the most striking factors in industrial progress in Germany, mentioning especially the importance attached in that country to technical education and the readiness with which the Authorities availed themselves of the services of the technical press. Mr. Gordon Selfridge compared the industrial conditions prevailing in this country with those in the United States, making a plea for the greater encouragement of young men starting in business with moderate capital, who were necessarily obliged to face some risk.

In conclusion, the following resolution was proposed by Mr. Hammer and seconded by Mr. L. Gaster (Chairman of the Circle), who alluded to the recognition given to the technical press in various other countries, in connection with the war :—

" That in view of the importance of British trade organisation after the war, and of the services which the scientific, technical, and trade press is in a position to render by the collection and analysis of information bearing on the trades with which they are associated, and in advising

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upon the reconstruction of the respective industries with which they deal, this Conference of Editors of trade and technical journals urges upon the President of the Board of Trade the desirability of utilising to the fullest extent the resources of the trade and technical press, and suggests as a first step to this end the formation of a joint committee representing the existing associations of scientific, trade, and technical journals for consultative, propagandist, and similar purposes."

The resolution was carried unanimously, and a vote of thanks to Mr. Garvin and Mr. Sowoll terminated the proceedings.

## PERSONAL.

Mr. J. Herbert Parsons has been appointed consulting ophthalmic surgeon to the Forces with the rank of Colonel, A.M.S. As a Vice-President of the Illuminating Engineering Society, a member of the Departmental (Home Office) Committee on Lighting in Factories and Workshops, and a member of the Committee on Illuminating Engineering under the Department of Scientific and Industrial Research, Col. Parsons has taken a keen interest in lighting, and readers will doubtless be interested to hear of his appointment.

# REVIEWS OF BOOKS.

*The Empire Municipal Directory. (Published by the proprietors of "Municipal Engineering and the Sanitary Record," 8, Bream's Buildings, London, E.C. 5s. net, post free 5s. 6d. 378 pp.)*

THIS directory, the 36th annual issue of which has recently appeared, fulfils a most useful purpose. It affords particulars of all Corporations, County, Borough, Urban and Rural District Councils and Port Sanitary Authorities in Great Britain, and the names of all the chief officials. It deals with municipalities, &c., in the chief Overseas Dominions, and the Government Departments concerned with Local Government Administration, and with Municipal Engineering, Public Health, and Scientific institutions and societies. Finally there is a record of all Acts of Parliament, Orders and Regulations passed since 1914. We have thus much useful information in a condensed, readily available form.

In addition there is a series of articles reviewing progress in various subjects of interest to sanitary and municipal engineers. We note a special contribution on Public Lighting, and there are also sections dealing with such matters as Road Engineering, Housing and Town Planning, Sewage Disposal, Public Water supplies, &c.

We can recommend this Directory to all concerned with municipal and sanitary engineering, and we have no doubt that it will be of interest to many others working in other fields of technical knowledge.

*Presidential Address delivered to the Society of British Gas Industries by Sir Robert Hadfield.*

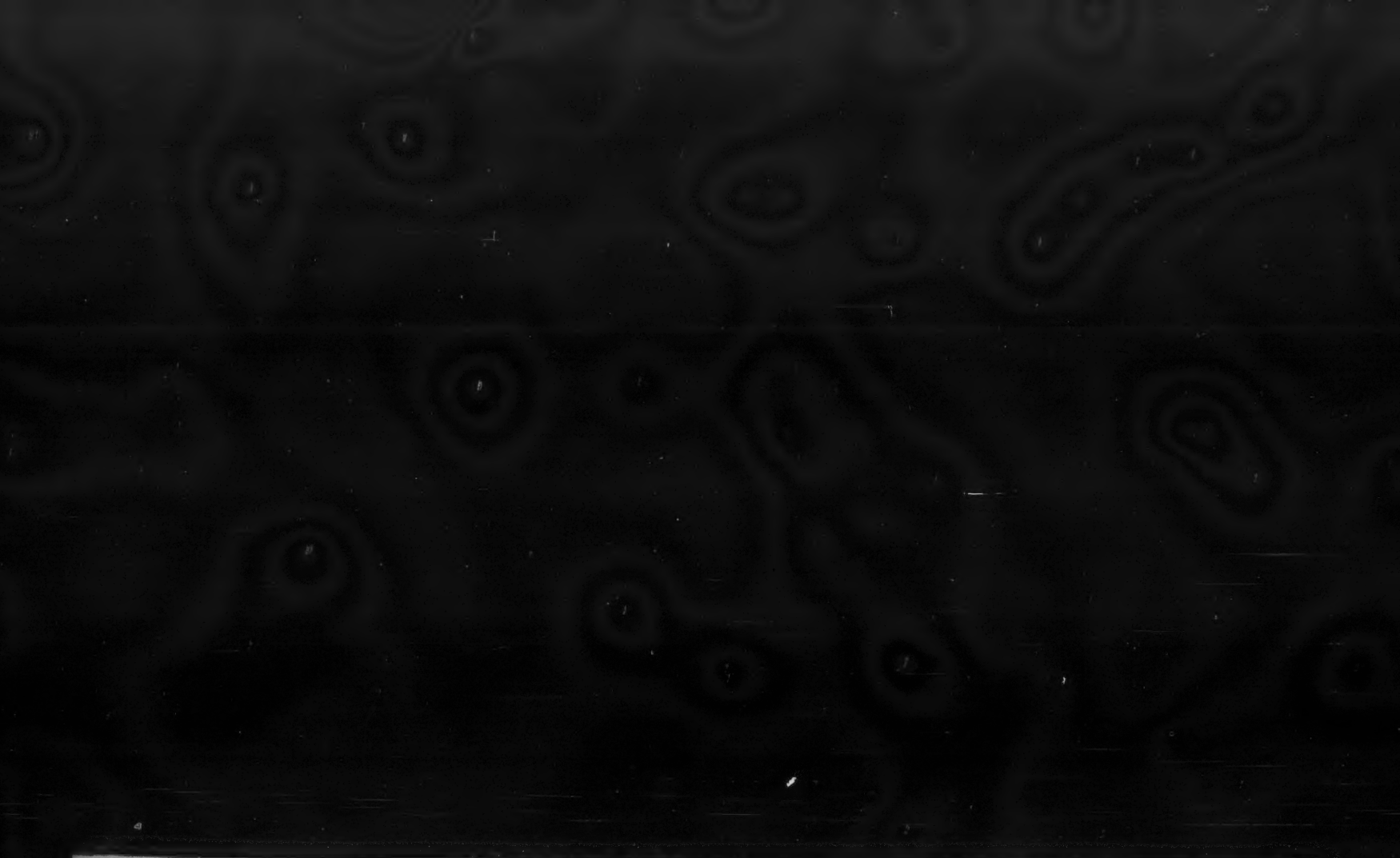
THE Presidential Address by Sir Robert Hadfield to the Society of British Gas Industries has been reprinted in volume form. We can recall few presidential addresses covering such a wide ground, or issued in such a comprehensive form. The address occupies ninety pages, and includes many plates and coloured diagrams. There are eight sections, dealing, among other matters, with fuel, gas, metallurgy, education, and commerce. The remarks on fuel and coal economy have a special application at the present moment, while the account of fuel and electrical consumption in relation to steel output at the Hadfield works and the sections on steel and metallurgy are of high technical interest. The views expressed on education, again, deserve close study. We cannot resist quoting the remark of the late Lord Salisbury, with which Sir Robert concludes his address :—

"We live in a small bright oasis of knowledge, surrounded on all sides by a vast unexplored region of impenetrable mystery, and from age to age the strenuous labour of successive generations wins a small strip from the desert, and pushes forward the boundary of knowledge."

Sir Robert's address is at once a picture of the general advance now being made, and a reminder of the vast tracts still to be won.

*The British Journal of Ophthalmology (Jan.—May, 1918).*

Recent issues of the British Journal of Ophthalmology contain a number of notes of interest to those outside professional circles. We notice, for example, contributions on the eyesight of engine drivers, on school lighting, and on a method of examining eyes by "red-free" light, which seems to favour the detection of some phenomena. An interesting discussion has also been taking place on the requirements in eyesight of men in the army and aviators.



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THE JOURNAL OF SCIENTIFIC
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OFFICIAL ORGAN OF THE
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(Founded in London, 1909.)

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Tel. No. 5215 Victoria.


# EDITORIAL.

## The New Household Fuel and Lighting Order (1918).

During recent months the question of economy in fuel has received constant attention from the Authorities, and its relation to lighting was discussed before the Illuminating Engineering Society on May 14th. On pp. 134–138 we give an account of this discussion, in which various points in the Lighting, Heating and Power Order (1918), issued on March 26th, were discussed. This measure was admittedly a temporary expedient intended to encourage economy in the use of gas and electricity and thus facilitate saving in fuel.

In order to afford the public some guidance in the methods of attaining this result, it was recognised as expedient for the Society to frame some simple recommendations on economy in lighting, such as could be applied by the consumer irrespective of any alterations that might be made in the Order. This series of recommendations, which is issued by the Society

with the concurrence of the Board of Trade, is reproduced on pp. 131–133. They give expression to the principle, which has always been approved by the Society, that *waste of light* should always be avoided, but especially at the present time when it is so essential to exercise economy in the use of fuel. Attention may be directed specially to the data in the Appendix relating to consumption for various kinds of industrial operations, which will no doubt be useful as a guide to the assessment of premises of this kind.

The next development following this discussion was the address delivered at the meeting summoned by the Circle of Scientific Technical and Trade Journalists on June 7th, when the Controller of Coal Mines (Sir Guy Calthrop) explained the essential objects of the New Household Fuel and Lighting Order, shortly to be introduced. An account of the proceedings at this meeting appears on pp. 139–141. We should like to express our appreciation of the admirable precedent set by the Controller in thus bringing before the Press of the country the reasons for the Order, and thus preparing the public mind for its subsequent appearance, and ensuring a proper appreciation of the necessity of the measure. The memorandum distributed at the meeting setting forth the circumstances demanding economy, and the salient points in the Order, proved most useful in securing uniformity of treatment in the Press.

It has been amply demonstrated that the people of this country are ready to submit to any sacrifice *once its necessity is explained to them.* The various causes of the fuel-shortage were clearly explained in this memorandum, namely, the withdrawal of labour from the mines, the necessity of shipment of coal to our Allies, and the restriction of coastwise traffic. While the amount of coal to be saved by curtailment of lighting may appear small in comparison with the total consumption of fuel in the country, it must be remembered that the amount available for non-essential uses is necessarily less, and that in meeting the new situation " every little helps." So far as concerns lighting, with which we are primarily concerned, we shall gladly co-operate in any steps calculated to arrest needless extravagance, and in this term we must now include much that would formerly have been considered but a reasonable expenditure. We are only anxious that so far as possible injudicious lighting curtailments liable to be prejudicial to health, safety or efficient production should be avoided.

We must postpone a detailed account of the New Household Fuel and Lighting Order until our next issue, but it may be noted that the scheme permits of the joint rationing of consumers in coal, gas or electricity. For the purpose of relating these commodities, 15,000 cubic feet of gas and 800 units of electricity are regarded respectively as equivalent to one ton of coal. Each householder will receive an annual allowance of fuel according to the number of rooms in his house, and a corresponding supplementary allowance of gas or electricity for lighting. Consumers who find this lighting allowance insufficient, may, however, convert part of their fuel allowance into gas and electricity on the equivalent basis set out above.

Speaking generally, the effect of the Order will probably be to bear gently on poor people occupying only a few rooms, and to demand economies chiefly from those who have larger houses and more rooms heated and lighted than are strictly necessary. There will doubtless be points in such a comprehensive scheme that demand elucidation, but we have reason to believe that the Controller and his staff are giving sympathetic consideration to the needs of the public and are anxious to avoid undue hardship.

## Industrial Safety.

For some years there has been a growing recognition of the need for greater care in ensuring the safety of workers, and the vast loss of human life in the war should make us only the more careful to husband our resources of manpower at home. In all the chief civilised countries the subject had been actively considered by experts in the years preceding the war. The Home Office in this country has done much valuable pioneering work, and we should like to mention specially the Industrial Museum for the display of safety appliances which was erected shortly before the war, but has been temporarily converted to military uses.

It is quite clear, however, that on such a point as this something supplementary to official action is needed. Care in the use of machinery, the taking of simple precautions to avoid accidents—these are largely a matter of education. Hence it has come about that in various countries, especially in the United States, there have grown up organisations whose function it is to educate both masters and men in the use of safety measures. The London "Safety First" Council in this country has done admirable work towards diminishing the number of street-accidents, but there has not been any comprehensive effort to apply the same principles in the field of industry, where they are quite as vital.

By the resolution passed at the Industrial Safety Conference on June 12th, an account of which appears on p. 142, a National Safety First Movement, applying to industry as well as to streets, etc., has been initiated. As regards the proceedings at this meeting we cannot recall any occasion on which a movement started under happier auspices. The very representative audience that assembled was obviously in thorough sympathy with the aims expressed on the platform, and the cordial and sympathetic speeches of the Rt. Hon. W. Hayes-Fisher (President of the Local Government Board), the Rt. Hon. G. H. Roberts (Minister of Labour), and the Rt. Hon. William Brace (Under Secretary of State, Home Office), in addition to the messages of appreciation received from Sir Geo. Cave and other Government officials who were unable to be present, made it clear that the aims of the movement are receiving strong official support. Lord Leverhulme, who presided, fully corroborated the value of such a movement out of his own large experience of safety measures in industry.

The matter has a special interest for us because of the close relation existing between accidents and defective illumination, and it was therefore very gratifying to note the strong endorsement by the Minister of Labour as to the value of adequate industrial lighting. "Light" and "Safety" are closely associated.

There is one point in regard to safety we should like to emphasise—a point that was ably put in the introductory remarks of the Lord Mayor in opening the Industrial Safety Conference. The principle "Safety First" does not in the least convey any desire to avoid danger incidental to duty. On the contrary, it expresses the idea, which is one of the first to be accepted by the trained soldier, that life and limb belong to one's country, and must not be risked by neglect of justifiable precautions. Few people realise the large list of reported accidents in this country, which in the year 1914 amounted to approximately 160,000, of which nearly 1,300 were fatal. The economic loss to the country through these accidents must be considerable, and we do not doubt that in this country, as in others, expenditure on judicious efforts to educate employers and workers in the use of safety measures and appliances will be amply repaid.

## The Final Report of the Health of Munition Workers Committee.*

To their admirable series of bulletins must now be added the Final Report of the Health of Munition Workers Committee, which includes a vast amount of detailed information and formulates some most important conclusions.

Later experience appears to have completely borne out the view regarding the drawbacks of excessive hours of work, especially at night, when, among other drawbacks, lighting is rarely so satisfactory as in the daytime, and supervision more difficult. The causes of fatigue have been traced in great detail, and it is shown that the loss of the powers of concentration that ensue are not only prejudicial to the quality of work, but are frequently responsible for accidents. We can only refer cursorily to the very varied contents of this Report, and in what follows deal chiefly with the references to lighting, which is naturally of special interest to our readers. It can scarcely be doubted that inadequate lighting, by increasing the strain of work, accentuates liability to fatigue, and this in itself contributes to the causation of accidents. An interesting report on the causation of accidents by Dr. Vernon mentions that in four factories investigated the number of cases of injuries to vision owing to foreign bodies entering the eye was 7–27 per cent. greater at night than by day, the difference being most pronounced in the least well-lighted factory, and the effect therefore attributed by Dr. Vernon to the artificial lighting conditions. Before drawing general conclusions from the Report as to the relation between lighting and accidents, however, the conditions under which this investigation was made require careful consideration, and we hope that further steps will be taken to elucidate one or two points therein.

Several striking special instances of the results of inadequate or peculiar lighting are mentioned. There are cases of injuries due to exposure to intense heat and light, *e.g.*, in welding operations. Again very convincing evidence is quoted regarding a section of a munitions works devoted to fuses, where the eye-defects actually formed 64 per cent. of those reported. This is ascribed largely to the effect of direct light entering the eyes, and reflection of strong light from polished parts, which are conditions naturally provocative of eye-strain. On the other hand, certain operations in " ball-viewing," which appear to require a weak diffused artificial light, also appear to be conducive to eyestrain, and it is suggested that this continued work in the absence of sunlight is undesirable.

We have referred above only to a few out of many interesting points in connection with lighting mentioned in the Report, which, in the special section devoted to this matter as well as in the general conclusions, endorses the chief conclusions of the Home Office Committee's Report on Factory Lighting.

There are many other questions which are well worth attention, notably the sections devoted to hours of work, canteens, washing and sanitary facilities, protective clothing, etc. The Committee are to be congratulated on the very useful work done, and especially the Chairman (Sir George Newman, K.C.B.) and Secretary (Mr. E. H. Pelham) on whom much of the labour devolved. The Report deserves study at the hands of all concerned with the supervision of factories and workshops, and forms a fitting conclusion to the Committee's work.

LEON GASTER.

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* Cd. 9065 (1918), published by H.M. Stationery Office, Imperial House, Kingsway, London, W.C.

# TRANSACTIONS

OF

# The Illuminating Engineering Society.

(Founded in London, 1909.)

*The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.*

## ANNUAL MEETING

(Proceedings at the Annual Meeting held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 6.15 p.m., on Tuesday, May 14th, 1918.)

THE Annual Meeting of the Society took place as stated above on Tuesday, May 14th, THE PRESIDENT being in the Chair.

The Minutes of the last meeting having been taken as read the HON. SECRETARY read out the names of applicants for membership announced at the last meeting, who were formally declared members of the Society.*

THE PRESIDENT then called upon the HON. SECRETARY to read the Annual Report of the Council for the Session November 1917—May 1918 (see pp. 128—130), which was duly adopted.

The HON. SECRETARY (Mr. L. Gaster) was then called upon to open the discussion on "**The Lighting, Heating and Power Order (1918) and the best methods of making Economies.**" In introducing the subject Mr. Gaster pointed out that the Society was interested in the maintenance of sufficient adequate illumination necessary in the interests of safety, health and efficiency of work, but was anxious to aid the authorities by suggesting methods of avoiding the waste of light—a principle which the Society had followed since its foundation. Accordingly a series of recommendations on Economy in Lighting had been prepared and were issued by the Society with the concurrence of the Board of Trade.

In the ensuing discussion Mr. E. Willis, Dr. J. F. Crowley, Mr. F. W. Goodenough, Mr. F. W. Willcox, Mr. J. S. Dow and the President took part, and Mr. Gaster briefly replied to some of the points raised in the discussion. A vote of thanks to Mr. Gaster for opening the discussion was carried with acclamation.

The President, in terminating the proceedings, announced that the first meeting of the next session would be held in November.

* *Illum. Eng.*, April, 1918, p. 103.

# REPORT OF THE COUNCIL FOR THE SESSION.

**(November, 1917—May, 1918).**

[Presented at the Annual Meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W., at 5.45 p.m. on Tuesday, 14th May, 1918.]

THE Report of the Council for the Session 1917—1918 appears in the fourth year of war, and the circumstances alluded to in recent Reports continue. Additions have been made to the list of members who have joined the Colours, and the number of those engaged wholly or partly on special war work has still further increased. Nevertheless the activities of the Society have been continued without intermission, and the membership has been maintained.

At the commencement of the present session Mr. A. P. Trotter assumed the office of President, in succession to Sir William Bennett, and has acted as Chairman of Council, and Mr. F. W. Goodenough has kindly consented to act as deputy-chairman.

## MEETINGS OF THE SOCIETY.

Four meetings of the Society, not including the Annual Meeting, have been held during the Session.

At the opening meeting on December 18th an address was delivered by the President, reviewing the work of the Society since its inception in 1909, and referring to the scientific aspects of the illuminating engineering movement. Allusion was made to the researches being undertaken by two committees of the Society for a Government Department on the illuminating power of star shells, flares and parachute lights, and on the brightness of fluorescent materials used for luminous gunsights. The address also dealt with the appointment of the Joint Committee on Illuminating Engineering under the Department of Scientific and Industrial Research and the subject of street-darkening for war purposes—a matter of considerable interest to the Society.

The second meeting, on January 15th, was devoted to a paper by the Hon. Secretary, Mr. L. Gaster, who recalled that it was just ten years since the proposition to form the Society was made, and reviewed the practical results of its work, and the prospects for the future. Attention was drawn to the need for further statistical evidence on various points such as the relation of illumination to accidents, the influence of inadequate illumination on vision, and the value of proper methods of illumination in regard to maintenance of output in factories, and quality of work. The importance of good illumination from these standpoints is well recognised, but it was suggested that fuller confirmatory evidence, and more detailed researches on various points that required further elucidation, would be extremely helpful to the work of the Society. Some tables illustrating the collection of information on the relation between illumination and accidents in streets and factories on a uniform basis, were presented, and the need for such data was emphasised by several representatives of the London "Safety First" Council who took part in the discussion.

On February 26th a paper was read by Lt.-Commander Haydn T. Harrison, R.N.V.R., entitled "A Survey of Methods of Concentrating and Directing Light." The Author, while necessarily debarred from referring to various aspects of the subject having a military or naval bearing, explained the principles underlying the design of projectors and searchlights of various types, and discussed the effect of varying the contour of reflectors so as to embrace an increasing proportion of the total light-flux. Some data on the results attainable from projectors used incandescent filaments were given, and suggestions were made for the use of such units in the lighting of interiors by indirect methods.

On April 14th Prof. W. M. Bayliss read a paper entitled "Light and Vision; the Physiology of the Retina." In the course of the paper he explained the

various steps in the process by which light is received by the eye, and ultimately analysed by the brain, pointing out the bearing of a knowledge of these processes on methods of lighting. In the latter part of the paper the practical bearing of the such data was discussed in greater detail, the need for researches on some debateable points emphasised, and the desirability of fuller co-operation between ophthalmic surgeons, physiologists and lighting experts endorsed. In the ensuing discussion the latter suggestion was strongly supported by various speakers, including the Presidents of the Ophthalmological Society and Medical Officers of Schools Association, and representatives of the Physiological Society.

### COMMITTEES AND CO-OPERATION WITH OTHER SOCIETIES AND ASSOCIATIONS.

During the past Session the Joint Committee under the Department of Scientific and Industrial Research has been continuing its work, one matter that has received special consideration being the important question of illuminating glassware. This matter was also the subject of a recent discussion at a small conference of members of the Illuminating Engineering Society, the Society of Glass Technology, and others directly interested in the subject.

Further work has been done by the two committees engaged in experiments on flares and parachute lights and on luminous gun-sights for a Government Department, and interim reports on both subjects have been presented. In addition suggestions have been submitted for the consideration of the authorities in regard to such matters as economy in lighting in relation to fuel saving, lighting arrangements for air-raid shelters, the desirability of obtaining fuller statistics on the effect of inadequate illumination in causing street accidents. Through its representatives the Society has been participating in the work of the London Safety First Council, especially the bearing of illumination on street safety.

At the Annual Meeting of the London Safety First Council a resolution was passed unanimously urging upon London lighting authorities the adoption of a diffused, substantially uniform illumination in all districts in the Greater London area where military exigences and local conditions permit, and advocating the use, after the war, of appliances to diffuse and screen the lights of street lamps, with a view to eliminating glare. The programme of the Safety First Council has recently been extended to include industrial matters which will doubtless afford opportunities for further educational work in connection with the proper lighting of factories.

The Society has also been considering the best means of furthering investigations on the hygienic and physiological aspects of illumination, and it is hoped that, as a result of the discussion of Professor Bayliss's paper in April, a Joint Committee will be formed consisting of members of the Illuminating Engineering Society and the Ophthalmological Society, to which all matters of mutual interest may be referred.

### EVENTS DURING THE PAST YEAR.

As on the occasion of our last Report there is little to be said regarding international developments in illumination. The Illuminating Engineering Society in the United States has been continuing its work with undiminished activity, and has also been afforded opportunities of rendering useful services to the United States Government in connection with the war. A National Committee on Lighting, appointed by Mr. Samuel Gompers will co-operate with the Council of National Defence in regard to the lighting of factories, mills, arsenals, etc.; a Committee on War Service has been appointed under the Chairmanship of Mr. Preston S. Millar, and sub-committees have been appointed to deal with such problems as the illumination of aviation cantonments and visibility at sea. Considerable progress has been made in legislation on industrial lighting. A number of States have revised their existing requirements on this subject, and others have introduced legislation for the first time, based on the code prepared by the American Illuminating Engineering Society.

An interesting event has been the formation of an Illuminating Engineering Society in Japan, with its headquarters at Tokyo.

In this country the course of events in regard to illuminating engineering has been broadly similar to that recorded during 1916—1917. The various steps that have been taken by various Departments to promote Economy in Lighting with a view to Fuel Saving have culminated in the "Lighting, Heating and Power Order (1918)," which is to be the subject of discussion at this Annual Meeting of the Society. While the Order will doubtless be loyally complied with by consumers, there is a general recognition that they require guidance, in order that economies may be made in a judicious manner, the aim being to avoid waste of light rather than to diminish illumination unduly in cases where the results of such a diminution would be prejudicial to health, of safety or efficiency of work. The Government in the United States have likewise been considering the desirability of economies in lighting with a view to saving in fuel, which was the subject of an interesting discussion before the Illuminating Engineering Society in that country on February 16th.

In the case of factories, especially those engaged on work of national importance, the desirability of avoiding any undue interference with the progress of work through inadequate lighting requires to be strongly emphasised. The results of inadequate illumination in causing eyestrain, in leading to accidents, and in making good and rapid work more difficult, have been recently emphasised in a booklet issued by the Health of Munition Workers' Committee, and in a recent statement by the Home Secretary in the House of Commons regarding the work of the Departmental Committee on Lighting in Factories and Workshops, stated that "good lighting in factories is of great importance to the health of workers and for the prevention of accidents, and has also a considerable effect on output." It is therefore to be hoped that any economies considered necessary will be exercised in such a way as not to conflict unduly with the requirements thus authoritatively stated.

At the same time the Society will gladly use its influence to prevent, in every way possible, the waste of light, thus carrying into practice the principles with which it has been identified since its foundation.

### Ten Years Anniversary of "The Illuminating Engineer."

With the commencement of the present year THE ILLUMINATING ENGINEER the official organ of the Society, attained its Tenth Anniversary, and the event has been celebrated by the issue of a special number of the journal, in which the progress of the illuminating engineering movement since its inception was surveyed. A large number of messages of congratulation were published, illustrating the wide interest now taken in the work of the Society, as a body of national value, with great possibilities of future development.

### Additional Support Required.

The Council are glad to be again able to record the gratifying fact of the Society being able to continue its labours, in spite of the unprecedented circumstances arising through the war. The considerations referred to under this head in their last Report apply with added force to the period 1917—1918. The Society is fortunate in benefiting by the arrangement by providing for THE ILLUMINATING ENGINEER to act as the official organ, and to undertake the publication of transactions the cost of which would otherwise be prohibitive. Many of the expenses incurred, such as those in regard to paper, printing, &c., have increased very greatly. The experience of the past year has served to emphasise even more strongly the desirability of securing additional funds in order to enable the work of the Society to be carried on in a satisfactory manner. It is to be hoped that the Society will secure substantial support from such institutions as benefit directly from the movement.

### Programme for the Next Session.

The Council is now engaged in preparing the programme for the next session. Members who are willing to read Papers are invited to notify the Hon. Secretary as soon as possible and to send in contributions during the vacation.

A. P. TROTTER, *President.*
LEON GASTER, *Secretary.*

*The following series of Recommendations on Economy in Lighting, issued by the Illuminating Engineering Society with the concurrence of the Board of Trade, was presented at the Annual Meeting of the Society on May 14th, 1918. An account of the discussion, dealing with these recommendations and various points in connection with the Lighting, Heating and Power Order (1918) will be found on pp. 134—138. The recommendations specify the most judicious methods of economising in the use of both gas and electricity for lighting, and apply generally irrespective of any modification in the Lighting Order that may be made.*

# RECOMMENDATIONS ON ECONOMY IN LIGHTING.

**(Lighting, Heating and Power Order, 1918.)**

***Issued by the Illuminating Engineering Society with the concurrence of the Board of Trade.***

## How to Make Economies.

(1) *Ascertain your past consumption.*

The local gas and electric supply undertakings will furnish you, on request, with a statement of your consumption for the corresponding quarters in 1916 and 1917, and explain the method of reading and entering figures registered on the meter. Examination of your gas and electricity meter-readings will enable you to see whether you are keeping within the prescribed limits. Readings of electricity meters give you the Board of Trade units (1 unit 1000 watt-hours) used, gas meters the cubic feet of gas.

Note that a

| | | | | |
|---|---|---|---|---|
| 10 | watt | electric lamp | used for | 100 hours |
| 20 | ,, | ,, | ,, | 50 ,, |
| 40 | ,, | ,, | ,, | 25 ,, |
| 60 | ,, | ,, | ,, | 16 hours 40 minutes. |

should consume in each case 1 unit (1000 watt-hours).

Electric lamps ordinarily used in private houses range from 10—60 watt. Incandescent gas burners, such as are used for domestic purposes, consume from 1—3½ cubic feet per hour according to size. Gas fires or electric radiators should be used only when strictly necessary, and may be dispensed with if the temperatures in the working area of the room is above 60° Fahrenheit. Cooking should be so arranged as to use ranges for a minimum length of time, and to their full capacity whilst in use. The use of hot water should be reduced to a minimum. In addition to economising in the use of gas and electricity for heating, *do not waste coal.* Use only what is essential for your requirements, which should be kept within the narrowest limits. Much that appears a necessity in time of peace is a luxury whilst we are at war.

(2) *To avoid waste of light.*

*First* avoid inefficient types of lamps or burners which consume an unduly large amount of gas or electricity for the illumination produced.

*Second* avoid extravagance in the use of light, using only the number of lamps, and the candlepower necessary for the purpose. (See Appendix.)

*Third* make sure that the lamps or burners are so placed and equipped as to give the maximum illuminating effect.

(3) *In selecting lamps and burners.*

Discard, as far as possible, carbon filament electric lamps which consume three and a half to four times as much electricity as metal filament (tungsten) lamps per

candle-power; and flat flame gas burners which may consume ten times as much gas per candle-power as is obtainable from modern (low pressure) incandescent burners.

In large rooms, *e.g.*, where the entire room is lighted by a chandelier containing a number of ordinary electric lamps, you may substitute gas-filled ("half-watt") electric lamps which again are about twice as efficient as ordinary tungsten lamps. A single gas-filled lamp may replace a number of small tungsten or carbon filament lamps of smaller candle-power, and should consume a smaller amount of electricity than the set of lamps discarded.

Replace, so far as possible, old and blackened electric lamps or corroded and worn out gas burners by new ones which will give the same light from a smaller consumption. If difficulty is experienced in obtaining new and efficient lamps and burners, the old and inefficient ones should be used, so far as possible, only in places where they are employed for short intervals of time, and not continuously.

Avoid so-called "cheap" gas burners, gas mantles, and electric lamps. They are wasteful in use and wear out prematurely. The use of good mantles and proper attention to the cleanliness of gas burners ensures economy by providing the best possible light for the gas consumer.

(4) *Use properly designed shades, globes and reflectors.*

To get the best results from any lamp or burner it should be equipped with a well-designed shade, globe, or reflector, screening the light from the eyes and directing it where it is chiefly needed. Do not use wrappings of silk or coloured paper which absorb a great deal of light. Substitute properly designed diffusing or prismatic glass devices, or cardboard or enamelled shades with white interior. In this way you can get the required illumination on your table or the working area from lamps of smaller consumption than would otherwise be necessary.

(5) *Keep lamps and illuminating accessories clean.*

If cleanliness is neglected lamps of unnecessarily high consumption have to be used to produce a given illuminating effect. Regular maintenance of gas lamps by the local gas company will be of assistance in keeping mantles, globes and chimneys in good order and preventing waste. Keep windows clean, thus making better use of daylight.

(6) *Where the illumination is excessive.*

Use fewer light-sources, or sources of smaller consumption, but avoid reducing illumination to values prejudicial to eyesight, cleanliness and safety. There should be sufficient light in kitchens and pantries where food is prepared and stored; in rooms where children do their home-lessons and where much reading and writing is done; on stairways where complete darkness may lead to accidents. Economy may fitly be exercised in drawing-rooms and dining-rooms, sufficient illumination being provided from local shaded lamps on tables where meals are laid, or reading and writing is done, and the rest of the room lighted in a subdued manner. Small lights (10 or 20 watt electric lamps or bijou gas burners) may be used in passages and halls or on landings, and should preferably only be turned on when such passages, etc., are actually in use.

(7) *Only turn on those lamps and burners which are strictly necessary, and turn them off immediately they are no longer required.*

It is a great advantage to have full facilities for the control of lamps through switches or cocks and bye-passes, so that the lighting of a room can be suitably subdivided and utilised in the most economical way.

***In any difficulty consult the local gas or electricity undertakings supplying your district.***

***These recommendations should be complied with irrespective of any modifications in the Order as regards rationing in coal, gas, or electricity that may be introduced.***

## APPENDIX.

RECOMMENDATIONS FOR THE ADEQUATE LIGHTING OF FACTORIES AND WORKSHOPS ENGAGED ON WORK OF NATIONAL IMPORTANCE).

The best way of making economies is to pay careful attention to the arrangement of lights. Proper positions and shading are quite as important as sufficiency of illumination. The essentials of good lighting are thus defined in the Report of the Home Office Departmental Committee on Lighting in Factories and Workshops (1915) * :—

(A) Adequacy.

(B) A reasonable degree of constancy and uniformity of illumination over the necessary area of work;

(C) Placing or shading of lamps so that the light from them does not fall directly on the eyes of the operator when engaged on his work or when looking horizontally across the room.

(D) The placing of lights so as to avoid the casting of extraneous shadows on the work.

As an indication of the amount of illumination, and the corresponding consumption of gas and electricity necessary for ordinary work the following table will be of service :—

| CLASS OF WORK. | MINIMUM ILLUMINATION ON WORK (*foot-candles*). | CONSUMPTION per 1,000 sq. ft. of working area. | |
|---|---|---|---|
| | | *Gas.* cubic feet. *Low pressure incandescent.* | *Electricity.* watts. *Tungsten lamps.* |
| Storage, passage ways, etc. .. .. | 0·25 | 3— 5 | 60— 100 |
| Rough manufacturing work .. .. | 1·25 | 15—25 | 300— 500 |
| Fine manufacturing work and offices .. | 3·5 | 40—60 | 800—1,200 |
| Very fine work on dark materials .. | 10—15 | (local lights) | |

N.B.—One foot-candle is the illumination received on a surface which faces a source of one candle-power at a distance of one foot.

As an example of the above table for workshops and factories, we may take a room, 60 feet long and 40 feet broad, devoted to fine manufacturing work. Such a room will require an illumination of about 3·5 foot-candles over the working area of the room, which will be somewhat less than its total dimensions, say 2,000 square feet. This might require a total gas consumption of 100 cubic feet per hour with low pressure gas, and the illumination could be conveniently obtained from the twelve evenly spaced gas lamps; if high pressure incandescent gas lighting is used, about half to one-third of the above consumption, and therefore half the number of lamps each consuming a similar number of cubic feet per hour might be used.

With electricity the required consumption, with ordinary tungsten lamps, would be about 2,000 watts, and the desired illumination could be obtained from twenty 100-watt lamps, evenly spaced and provided with appropriate reflectors. If gas-filled ("half-watt") lamps are used, six 200-watt lamps would be sufficient. One might select either of the alternative methods suggested according as the work requires "local lighting," from a number of smaller units at close intervals, or "general illumination" from fewer and more powerful sources. The consumption of gas or electricity necessary to yield a given illumination will naturally vary somewhat according to the positions and types of lighting fittings employed, and the nature of the surroundings (i.e., whether dark, medium, or light in tint). Accordingly some margin has been allowed in the figures given in the above table.

* Blue Book Cd. 8000 (1915). Obtainable from H.M. Stationery Office, or through any bookseller.

# THE LIGHTING, HEATING AND POWER ORDER (1918) AND THE BEST METHODS OF MAKING ECONOMIES.

(Discussion following the Annual Meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W., at 6.30 p.m., on Tuesday, May 14th, 1918.)

FOLLOWING the presentation of the Annual Report of the Council and the Recommendations on Economy in Lighting, reproduced in the foregoing pages, the PRESIDENT called upon Mr. Gaster to open the discussion.

Mr. L. GASTER stated that the avoidance of waste of light had always been a fundamental principle insisted upon by the Society, and in the present circumstances it was the special duty of everyone to bear this in mind. The issue of the recent Lighting, Heating and Power Order (1918) rendered further discussion timely, and the series of recommendations prepared by the Society and issued with the concurrence of the Board of Trade was intended as a guide to the public, who were much in need of information on the best methods of saving. Before referring more fully to these recommendations, he might make a few introductory remarks summarising the circumstances that rendered economy desirable, and the extent of the saving that might be anticipated through the Order.

The chief reasons for economy were the necessity for saving coal, owing to shortage of labour for working the mines and the diminution of transport facilities for its conveyance. Special local measures might also be found necessary in cases where the gas or electricity supply concerns found a difficulty in meeting the greatly-increased industrial or munitions demand. Mr. Gaster referred to the table, analysing the consumption of electricity for lighting for different purposes, presented by Mr. P. S. Millar at a recent meeting of the American Illuminating Engineering Society.* Residence lighting amounted to 24 per cent., and this was a field where reasonable economy might be encouraged. Spectacular and advertising lighting (4 per cent.) had been practically eliminated in this country. Although the amount of fuel involved was small, this curtailment was necessary, as otherwise the public might not appreciate the need to economise in their own homes. Street lighting (14 per cent.) had also been largely restricted, and, while less wasteful methods of diminishing the light from public lamps might be encouraged, it was undesirable, in the interests of safety, to make any further drastic reductions in London in the actual illumination on the pavement and roadway. In the case of industrial lighting (19 per cent.), great care must be exercised not to diminish the illumination to a value likely to be prejudicial to health, safety, or efficiency of work and output. Tests made at Chicago, under the direction of the Commonwealth Edison Company, showed an increase in production of 8—27 per cent. when the illumination was increased from 4 to 12 foot-candles—a value probably considerably above that provided in most factories in this country. Mr. Gaster also mentioned the case, quoted by Mr. R. E. Simpson in the discussion of Mr. Millar's paper,† of a firm who, in order to economise made a wholesale diminution in their lighting, with the result that the accident-rate increased, and one man was caught in revolving machinery and killed. The compensation paid in this case would have covered the entire expenditure on lighting in the mill for 17 months. This illustrated the need for care in making economies in lighting in factories.

Turning next to the possible economies to be accomplished through the operation of the Lighting Order, Mr. Gaster proceeded to give some figures for coal consumption in this country taken from the Interim Report of the Coal Conservation sub-committee on Electric Power Supply in Great Britain (Cd. 8880, 1917).

* Trans. Illum. Eng. Soc., U.S.A., March 20, 1918. *Illum. Eng.*, Lond, Feb., 1918, p. 56.

† *loc. cit.*

In 1913 the total output of coal was 290 million tons, the home consumption 190 million tons. Factories and the iron and steel industry consumed together about 91 million tons, railways 15 million tons, mines 20 million tons. The most hopeful field for economy was domestic consumption, which accounted for 35 million tons. Gas and electric supply concerns received respectively 18 million and 4 million tons. Assuming that about one-third to one-fourth of the yield of gas and electricity was used for lighting, and that every consumer in the country reduced his consumption by one-sixth, as the Order required, the saving would only amount to about 750,000—1,000,000 tons of coal per annum—about 0.5 per cent. of the total home consumption. It must be remembered, however, that owing to various special causes (such as the calling up of men in mines and on railways, the increased demands of the Navy, and the necessity of supplying some of our Allies with more coal than in pre-war periods), much less coal might now be available for all non-essential purposes, and even a small saving through curtailment of lighting might be welcome.

Mr. Gaster made a plea for sympathetic consideration to be given to the cases of factories which were not controlled by Government, but yet engaged on work of National importance (such as Army clothing contractors, caps and boot manufacturers, etc.). It was obvious that the comparison with past quarters became difficult in the case of businesses which were rapidly expanding, and where an increase in night work had been found necessary. Reduction in lighting should be enforced only in cases where there was an obvious waste of light, and not when such a reduction would occasion possible accidents, damage to health, or diminution in output and inferior work. Assessors with experience of lighting problems, and an adequate knowledge of the requirements of the industry concerned, should be appointed to decide difficult cases.

It must, however, not be forgotten that supplies of gas and electricity were always dependent upon the ability of the undertakers to furnish them, and it was an imperative duty for all users of gas and electricity to exercise the utmost care in the use of coal, gas and electricity, and to prevent any waste of these commodities.

Mr. Gaster added that he had every reason to think that the Board of Trade would give this matter careful attention, and that each case would be considered on its merits if the claim for exemption was supported by the Government Department for whom the contractor was carrying out the work of national importance.

Mr. Gaster also referred to some debatable points in the Order which, however, was essentially an emergency measure designed to relieve gas and electricity companies during the summer months and enable them to husband supplies of coal for the winter, when the scarcity might otherwise become acute. Consumers should understand that burning coal in the domestic grate was a much less efficient process than its use by gas and electrical supply companies, and the case of a man who had already been using gas in preference to coal for heating deserved sympathy. Would it not be possible to meet all such cases by a combined ration in coal, gas, and electricity? The proportional value of these commodities might be computed on the assumption, say, that one ton of coal was equivalent to 800 units of electricity, and a heating value the same as could be obtained from the efficient use of 12,000—15,000 cubic feet of gas; due consideration being given to other advantages in the use of gas, such as the production of coke and many valuable by-products used in the manufacture of explosives, fertilisers, etc.

In conclusion, Mr. Gaster explained the objects of the recommendations on economy in lighting issued by the Society. He pointed out that these applied both to gas and electric lighting, and were correct as a matter of principle, irrespective of any modifications in the Order that might be made. The suggestions were designed to enable the ordinary consumer to economise in the most judicious directions; for example, by avoiding inefficient types of lamps and appliances and the use of unduly powerful lamps in halls and passages, and by checking extravagance in the lighting of

drawing-rooms and dining-rooms. Care should, however, be exercised in diminishing illumination in study rooms where children did their home lessons, and in kitchens where food was prepared.

Special attention was drawn to the data presented in the Appendix relating to industrial lighting, which, it was hoped, might be useful as a guide to the assessment of the requirements of factories. The values were based on wide experience in this country and in the United States, and would afford an indication of the consumption that might be regarded as necessary for the efficient performance of various classes of work.

Mr. E. WILLIS said the Order was of vital importance to the nation at large, and it had a particular interest to him as one of the coal overseers for London. He believed it was an honest attempt of the Government to feel its way, and to deal with the whole problem equitably. There was no question that the nation was in sore straits as regards coal, and it would be in a very much more difficult position before the end of the next winter. Coal was such an essential for the production of light and power that it was imperative for the Government to regulate the domestic use of it in order that it might be put to the best advantage by the power and gas companies. His own view was that the Coal Orders would have to be combined with the Lighting, Heating, and Power Order. The main difficulty that the Coal Overseers had to deal with was the domestic consumption, and they had had a general order to the effect that it must be cut down by one-sixth. Personally, he believed that in many houses it would be cut down considerably more than that, and one of the means of reducing the domestic coal consumption would be the communal kitchen. He had had a little to do with the working of a communal kitchen, and could not help feeling that properly worked they should prove a distinct advantage.

It was necessary to differentiate between power for industrial purposes and power for cooking. The latest Order was an attempt of the Government to feel its way, and everybody should help to the best of their ability. It was an admirable idea that the Society should ventilate the subject; it was the first discussion before any Society, nor had he seen it discussed in any of the professional papers, and if the Order could be varied to deal with the points he had mentioned the Society was to be congratulated on having achieved a good result. Whilst in factories we must be prepared for a large consumption of electricity and gas, and whilst there had been considerable economies effected, he thought there was room for still further improvement in that respect by a rearrangement of the periods between which the different gangs started work. Then he had noticed in some factories that during meal times the light was left burning.

With regard to public lighting, he believed that some districts had done their best; in fact, some districts were extremely dark, but he was coming to the conclusion that it would be necessary to cut out the lighting altogether in the side streets right through the night. It had been done in the outlying districts, and he thought it should be carried out in greater London. It was the combination of these economies which would help the nation. The Coal Order was now to be applied to the whole of the country, and in that connection the Coal Controller had not quite had that assistance from the merchants which he had looked for, because the tendency was to tell everyone to go for their maximum quantity. Economies were also being exercised in connection with the lighting of trains and trams, but only in some directions. Where there were only a nominal number of passengers it should be possible to extend the economies in this direction by concentrating the passengers in a few carriages and extinguishing the lights in the rest. He hoped when the Government appointed assessors in connection with the Lighting, Heating, and Power Order that they would appoint gentlemen versed in the science of illumination.

Dr. J. F. CROWLEY remarked that the proposals in the Order were presumably tentative, and some discussion might therefore be helpful. The diagram presented by Mr. Gaster had clearly indicated the possible limits to saving, and if this information were more widely

known it would correct much current misapprehension. There was a marked difference between economies in heating and lighting. The former might occasion discomfort, but the latter, if incautiously applied, might lead to serious accidents. In aiming at economies in lighting the authorities no doubt had in view the improvement of load factors of electric generating stations, In some instances the "peaks" in the load were highly inconvenient and their elimination might release generators badly needed for other purposes.

The burning of coal in the domestic grate was a most inefficient process. He recalled that a German doctor had informed him, as the result of accurate records in both countries, that he required in this country twice the coal to heat his house that was employed in Berlin. If more heating were done by gas, considerable economies in the use of coal for domestic purposes might be made. This point appeared to be insufficiently emphasised in the Order, and deserved attention from the authorities.

Mr. F. W. GOODENOUGH said he believed that consideration was being given to the point raised by Dr. Crowley in regard to people who had installed gas-heating apparatus in order to reduce the consumption of coal, and in that connection it might be interesting to mention that experience had shown pretty conclusively that 750 tons of coal sent to the gas works and turned into gas and coke would do as much useful work in the direction of heating and cooking as 1,000 tons of coal used crude. That meant a saving of 25 per cent. of the country's resources in the quantity of coal to be mined for the work to be done, and it very materially reduced the amount of transport required both from the pit to the town and the transport entailed in the town in the case of crude coal.

As to the comparative cost of heating in Berlin and London, it was necessary to bear in mind that the climate of Berlin was much more suited to central heating than the climate of London, and apart from the fact that the German preferred to be stewed whilst the Englishman preferred a little fresh air, they had spells of consistent cold in central Germany, as in Canada and Russia, when continuous heating was required for long periods, whereas in this country it was still true, as the American remarked of us many years ago, that we have not got a climate but only a collection of samples. Our weather so constantly varied from days when we needed warmth to days when we would gladly throw off our heavy clothing, that any form of central heating was hardly suited to the British climate, and it was only likely to be adopted by the few people who liked what he would call excessive heating, or in those cases where it was used merely to take the chill off the rooms in blocks of buildings, leaving the "comfortable" warming to be done either by open fires or gas fires or some other means of heating. If central heating was used to raise the temperature of a room above quite a modest figure, unhygienic conditions were produced and conditions which he considered caused great discomfort.

Reference had been made to the small savings to be made in lighting compared with the consumption of coal for fuel purposes, but he thought, although he had no particular authority for saying it, that the object of the Government in restricting lighting was as much for the psychological effect as for the actual economical effect, because nothing brought home to people the call for economy more than to see the show lighting they had been accustomed to in the shop windows cut down drastically, and nothing could bring it home more than the suggestion made by Mr. Willis that when the trains were being run partially filled, the passengers should be required to concentrate in a portion of the train and the remaining portion left in darkness. There was a tendency for a huge producer of electric current like the Underground Railways to regard the quantity used for lighting as a purely negligible fraction and to splash it about freely. In peace times we appreciated being able to read in the railway carriages easily and having ample lighting on the platforms, but in war time we had got to put up with something less than the best.

There was undoubtedly a very great amount of economy to be effected in munition factories, more particularly at

the present time, and one of the particular factors making for waste under present conditions was the arrangement under which a good many factories were working whereby they were not paid a fixed price for what they produced, but were paid a percentage on their costs. There were many Government contracts running on that basis which was absolutely a premium on waste, and the more time that was wasted and the more light and heat that were wasted, the higher the costs and the bigger the receipts. If the Government could get away from that very pernicious system as soon as possible, very big economies could be effected. He had heard of cases where gas burners for soldering irons had been left burning during the whole of the dinner hour, 60 or 70 soldering stoves left fully alight, and when a protest was made by a gas man as to the waste entailed, he was told "What does it matter to us? We are paid according to our costs."

As to public lighting, the proposition to turn out the lamps in the side streets after midnight was one which would have to be considered by the police before it could be put forward for acceptance by any responsible body, because there was the old saying that "a lamp is as good as a policeman," and it was a question whether the police would agree to the side streets of London being left in darkness after midnight. So far as gas and electricity were concerned, labour would be entailed in turning the lamps out, because metal filament lamps were not controlled from the central station but individually, in the same way as the gas lamps, and it had often been calculated out that the cost in labour to turn the lamps out at midnight was more than the saving in gas was worth. Therefore, from the point of view of economy there was nothing in it, and labour at the present time was a very great difficulty all round.

Dr. CROWLEY, as one who had worked with the Special Constabulary for a considerable time, strongly supported Mr. Goodenough's remarks, regarding diminution in street lighting.

Mr. F. W. WILLCOX agreed that the coal saving through restriction of electric lighting was very small. Mr. Preston Millar* had shown that of 50,000,000 tons which the United States Government desired to save, only 360,000 tons could properly be saved in this way; whereas if every family in the United States decreased their daily use of coal by one shovelful, the saving would be 15,000,000 tons.

In the present circumstances, however, "every little helps." Fortunately in illuminating engineering work there were many opportunities of saving by improvement in methods of using light, *e.g.*, the adoption of lamps and fittings of improved efficiency. For example, it was estimated that if all the carbon filament lamps in this country were replaced by metal filament or gas-filled lamps, there would be an annual saving of 500,000 tons of coal.

Again, the general introduction of scientific lighting appliances was capable of at least doubling the efficiency of the average installation. While the total amount of saving possible was small, the actual percentage saving was high. The new lighting regulations presented a unique opportunity to members of the Society to apply the principles with which it was identified.

The PRESIDENT said that the discussion had raised some interesting points. The chief defect in the Order was that it pressed most severely on consumers who had already done all they could to economise. It was desirable that regulations should be so framed as to encourage the use of electricity and gas rather than coal in the grate. It was quite obvious that coal used in a gas or electricity works was used far more economically than in the domestic household.

He agreed that great waste was involved in the present methods of restricting street lighting, and this was not the first time that attention had been drawn to the point at meetings of the Society. The company that was responsible for the lighting of Westminster had asked to be allowed to replace the arcs by 60 watt metal filament lamps, which would give all the light required and save about £2,000 a year, but as yet nothing had been done.

(*Discussion to be continued.*)

# THE NEW HOUSEHOLD FUEL AND LIGHTING ORDER (1918).

AT a meeting called by the Circle of Scientific, Technical, and Trade Journalists, at the Institute of Journalists on June 7th, an address on the New Household, Fuel and Lighting Order was given to a representative gathering of journalists by the Controller of Coal Mines (Sir Guy Calthrop, Bart.).

Mr. L. Gaster, Chairman of the Circle, who presided, offered the congratulations of the meeting to Sir Guy on his elevation to the Baronetcy, and expressed their appreciation of the recognition he had paid to the services of the Press in coming to address them on this important subject. The rationing of coal, gas and electricity was necessarily an intricate matter, and the co-operation of the technical and daily Press would no doubt be very useful in making the Order clear to the general public and to manufacturers in various industries. Nothing had been more striking since the outbreak of war than the readiness of all sections of the public to make any necessary sacrifice, once they appreciated the urgency and the nature of the circumstances through which it arose. People as a whole, perhaps, hardly realised sufficiently the vast importance, both in peace and war, of coal and transport, and the difficulty of allocating to many different departments and industries their appropriate share. Sir Guy had kindly come to enlighten them on these points, and he felt sure that the preliminary information he could convey would be most useful in educating the public to appreciate the salient points of the Order and its aims and object. He also hoped that, after the Order was issued, the Controller would make use of the daily and technical Press as a vehicle through which an explanation of any difficult points could be conveyed to the quarter concerned. If editors of technical journals could bring to the Department any special difficulties encountered by the industries which they represented, and receive the proper interpretation for transmission to their readers, this would save a great deal of correspondence, and help materially towards a general understanding of the Order.

Sir Guy Calthrop said that he was very glad to have the opportunity of bringing this matter before the notice of the Press, and he felt sure that their co-operation would be most helpful in making the facts generally known. It was important to recognise that the position in regard to supplies of coal was now very different from what it had been at the commencement of the year. Among the factors which had contributed to the shortage were the withdrawal of a large number of miners from collieries, causing a probable reduction of 20 million tons in the year, the increased requirements of our Allies, and the restrictions on coastwise shipping.

The Lighting, Heating and Power Order, issued at the end of March, had been framed to meet the emergency, and was intended to assist the gas and electric supply companies in restoring their coal supplies, which had become very seriously depleted, before the winter period arrived. But in any case the need for economy in the use of fuel during the coming winter would be very urgent, and in the new Household Fuel and Lighting Order, to be issued shortly, it was intended to apply a much wider scheme, involving the joint rationing of coal, gas and electricity. In considering fuel rations it had been decided, after consultation with experts, to take 15,000 cub. ft. of gas and 800 units of electricity as doing duty equivalent to one ton of coal. The new Household Fuel and Lighting Order would include the consumption of coal, gas and electricity, and the consumer could elect to take the allocated fuel-ration in these three commodities on the equivalent basis set out in the Order. An allowance for lighting, either by gas or electricity, and supplementary to that made for fuel, would also be provided for in the Order. There would also have to be rationing of coal for industrial purposes,

and some sacrifice might have to be exacted from those industries not directly occupied for the prosecution of the war. The Coal Control Department would, however, consult authorities representing the various trades, so that the least inconvenience and hardship should arise. The scheme would affect all parts of England, Scotland and Wales, and District Light and Coal Committees would be set up in each district, armed with adequate powers to secure the working of the Order on an equitable basis.

In the ensuing discussion a number of points in connection with the operation of the new Order were raised, including the position of coke, Sir Guy stating that three tons of coke would be regarded as equivalent to two tons of coal.

The proceedings terminated with a hearty vote of thanks to Sir Guy, which was moved by the Chairman and seconded by Mr. P. Gilbert Wood. In the course of the proceedings a memorandum summarising the chief points in the new Order and the circumstances rendering it necessary was distributed, and we reproduce this in what follows :—

## The Household Fuel and Lighting Order (1918).

### Introductory Memorandum.

1. The object of this Order is to save coal. Not less than a quarter of the coal previously available for domestic use and consumption must now be saved. If household coal alone had been considered the saving required would have necessarily been greater, but it was felt that it would be unfair to make heavy reductions in the supply of coal, if gas and electricity for fuel had been allowed to go free. The saving required has, therefore, been distributed over all three, and a household may take the fuel it requires as gas or coal or electricity up to a given total quantity according to its size and needs. If it takes less coal it obtains more gas and *vice versa*.

As gas and electricity for lighting are usually supplied through the same meters as gas and electricity for fuel, the Order necessarily extends to cover this. Allowances for lighting are set out in the Order following the allowances for fuel.

2. The method of relating coal, gas and electricity is to fix a fuel allowance in tons and to permit of the substitution of 15,000 cubic feet of gas or 800 Board of Trade units of electricity for one ton of fuel.

Fuel may be converted into gas or electricity at the option of the consumer by quarter tons, but not by a less fraction.

Much consideration has been given to these equivalents. There are two governing factors. First of all the amount of gas or electricity required by a consumer to obtain the same effective service as the burning of a ton of raw coal. Second, the amount of gas or electricity to be produced by the consumption of a ton of raw coal at the gas or electricity works. There is no necessary correspondence between these two factors, and the result adopted represents a fair and proper compromise.

3. Owing to the importance of carbonising coal in gas works in the interests of the nation as a whole, it is not desired to restrict the consumption of gas if it can be produced and used in place of raw coal.

Coal, when carbonised at a gas works, in addition to providing gas, provides also a quantity of fuel oil, of tar, of fertiliser (sulphate of ammonia), of coke, and from these products in turn are made a variety of drugs, chemicals and explosives. There is a distinct national gain at this moment in consuming gas and coke in place of coal.

Unfortunately, for various reasons, it is not possible to manufacture sufficient gas in certain districts to meet the demands of consumers, and in those districts it will be necessary to reduce the quantity of gas allowed for each ton of fuel to a less figure than 15,000 cubic feet. The minimum figure may be 12,000 cubic feet, but even this will give satisfactory service to the consumer. Similarly, in more fortunate districts it may be desirable to stimulate the consumption of gas, and in those districts the allowance may be increased up to a maximum of 18,000 cubic feet. It is not possible to avoid this inequality, but it may be observed that the higher equivalents will apply chiefly in the North and will compensate for the colder climate. These modifying adjustments will only be made when experience of the working of the Order has shown them to be imperative.

The production of gas will further be dependent upon the demand for gas by consumers.

The advantages of electricity chiefly relate to power and lighting, and therefore need little comment in this connection.

4. There is a serious shortage of coal which has made this effort at economy unavoidable. This shortage is due to several causes :—

(*a*) The withdrawal of 75,000 skilled miners from the collieries, which means a reduction in output of 20,000,000 tons of coal in the year.

The needs of the Army overshadow the needs of our comfort.

(*b*) The requirements of the Allies. The coal essential to the war industries of France and Italy has now to be found by Great Britain almost wholly. Coal is also sent to neutral countries in exchange for the food and supplies needed by us. It is a valuable coinage in itself these days, and much more worth its weight in gold than ever before.

(*c*) The restriction on coastwise shipping, occasioned by the submarine menace, has aggravated the strain thrown upon the heavily-burdened railway system and, apart altogether from the quantity of

coal available, a reduction in the quantity to be moved is inevitable.

This Order deals with household coal only, but includes in this supplies for home industries and for bakeries, laundries and other businesses which may be used in substitution for household work. It also includes supplies of coal for heating and cooking wherever used. Later on it may be necessary to proceed to the rationing of coal for industrial purposes of all kinds not directly associated with the conduct and support of the war.

Control in itself is unpopular, but it must be accepted as the least of evils.

5. The administration of the Order rests on two principles. One: that the Local Authority must have a predominant voice in securing the welfare of the ultimate consumer, the public. Two: that this is no time to improvise new machinery, and the co-operation of the coal trade and of the gas and electricity undertakings throughout the country is welcome. As far as possible, trade must continue in the same channels and by the same methods as hitherto. By happy agreement this co-operation is assured.

Local authorities, acting singly or in partnership throughout the country, will set up Local Fuel and Lighting Committees composed of representatives of the trades and industries concerned on the one hand and a majority of independent members on the other hand. These Committees will have as Executive Officer a Local Fuel Overseer capable of giving effect to the provisions of the Order and of enforcing them. . . . .

The Local Fuel Overseer will be advised by representatives of the trades and industries affected for that purpose.

6. Any scale of allowances cannot be expected to meet all possible combinations of circumstances. There will always be exceptional cases and cases of hardship. One duty of the Local Fuel Overseer will be to consider and deal with such cases under the guidance ofthe Local Fuel and Lighting Committee.

Another aspect of the scale may be noted here. It is not possible to secure any appreciable economy in consumption in the smallest houses. The cost of the supplies of fuel has always been a warning to the most careful consumption. As the size of the house grows, the consumption of fuel has usually grown at a greater rate. This cannot now be permitted, and it may be observed that the scale will proceed on the even basis of one ton of fuel per room up to 20 tons, commencing with a minimum quantity of 3 or 4, or even 5, tons according to the climatic and other conditions prevailing in the district. For it is not thought feasible and right to enforce an identical scale upon all parts of the country. There must be a saving in fuel at all stages, but there must be a greater saving among larger houses to make up for the less saving among the smaller houses.

At first sight it may look to those unfamiliar with the facts as if there were practically no saving required in the larger houses, but this is to misjudge the situation. The enforced saving will amount to 50 per cent. in numberless cases, and even more. It is only fair that this point should be noted.

7. All schemes of control carry with them certain concomitants such as:—

The registration of distribution agencies,
The fixing of maximum prices,
The establishment of reserves,
The registration of customers,
The checking of supplies and deliveries.

and this Order will be found to contain provisions to deal with all those points.

In particular, attention may be drawn to the restrictions to be placed upon private stocks of coal and upon deliveries of coal. No one may have an excesssive stock of coal, which is limited to one year's allowance. It is desired that as far as possible all those who can should stock their due supplies of coal in the summer time so as to leave the merchants free in the winter to meet the requirements of those less advantageously placed. Every possible economy in man power and cartage must be obtained, and so it is important that as much coal be sold in the summer months to put into store as in the winter for use. During the winter months a preference must be given to the demands of small consumers. The movement of truckloads of coal to private consumers is brought under severe check, and may be entirely forbidden at any moment when the needs of the situation make it desirable. Similarly, all consumers can, if needs be, be brought down to a minimum monthly delivery of a ton of coal.

8. The Order may appear formidable. Certainly there are many clauses carrying with them penal consequences. Whether they are to be put into operation depends upon the public spirit and honesty of those of whom they concern. It is hoped that few prosecutions will be necessary, and that many of the clauses may remain a dead letter. But it should be understood that those persons responsible for the administration of the Order are armed at all points and will not hesitate to enforce the measures laid down against offenders.

To check the consumption of coal is relatively easy. When the allowance has been delivered all further deliveries can be stopped. With gas and electricity it is not so easy. They are constantly available in the house until the supply is cut off, which cannot take place until an excess quantity has been consumed.

It is intended, where gas or electricity are consumed in excess, to curtail supplies of coal to offset such excess. It is intended to enforce the provisions of the Order as to economies in gas or electricity consumption if not by direct prosecution (though this remedy is available) by indirect means.

This Order is made under the Defence of the Realm Regulations, and any offence under it is punishable in a court of summary jurisdiction by imprisonment with or without hard labour not exceeding six months or by a fine not exceeding £1,000, or both.

Coal Mines Department—Board of Trade.
Household Fuel and Lighting Branch,
Holborn Viaduct Hotel,
London, E.C.1.
7th June, 1918.

# INDUSTRIAL SAFETY.

The Industrial "Safety First" Conference at the Mansion House on June 12th marked a new stage in the development of the "Safety First" movement in this country, namely, the extension of its work on street-safety to the industrial field. The meeting was a most representative and enthusiastic one, and augurs well for the prospects of the new departure.

The Lord Mayor, in extending an official welcome to the Conference, remarked that the term "Safety First" was not to be understood in any derogatory sense; it did not imply any avoidance of danger incidental to duty, but merely the principle, recognised as a primary duty by the soldier on the battlefield, that his life belonged to his country and must not be wantonly sacrificed by disregard of any justifiable precaution. At the present time, when so many valuable lives were being lost in the war, it was very desirable to limit the loss of life and limb in industry at home.

After Lord Leverhulme had been invited to take the Chair, and had expressed the thanks of the meeting to the Lord Mayor for his welcome, Mr. H. E. Blain (Joint Hon. Secretary of the London "Safety First" Council) read a number of messages expressing regret at inability to attend.

Lord Leverhulme opened the discussion by an instructive address, in which he dwelt upon the very valuable results following the initiation of the safety first movement in the United States, where the number of accidents had been relatively higher than in this country. In Germany also the introduction of safety appliances and educational measures had resulted in a saving of many millions of pounds per annum. He could speak from practical experience of the benefits of educational safety measures in his own works, and he felt sure that the movement in this country had a great future before it. He had much pleasure in moving the following resolution:—

"That this meeting do pledge itself to support a National Industrial 'Safety First' Campaign, and that the London 'Safety First' Council be requested to take the preliminary steps to establish the necessary organisation."

The resolution was strongly supported by the Rt. Hon. W. Hayes Fisher (President of the Board of Trade), the Rt. Hon. G. H. Roberts (Minister of Labour), and the Rt. Hon. William Brace (Under-Secretary of State for the Home Department), all of whom spoke in warm terms of the objects of the movement. Mr. Hayes Fisher, in expressing the sympathy of the Local Government Board, remarked that the interest of this country had always been strongly manifested in measures for the promotion of safety and hygiene in factories. Mr. Roberts pointed out that the initiation of safety measures was a matter in which both the employer and worker were jointly interested, and might well fall within the scope of the industrial councils which it was hoped would be established for all the chief industries of the country. He emphasised the drawbacks of working in factories where hygiene and safety were insufficiently cared for, and he regarded a properly heated, ventilated and lighted factory as essential to safe and efficient work. Mr. William Brace referred to the large number of accidents tabulated in the Annual Reports of H.M. Chief Inspector of Factories, which illustrated the need for a better appreciation of the value of safety measures. The Home Office would welcome any steps calculated to bring about an improvement in this respect, and entirely sympathised with the aims of the movement.

A vote of thanks to the Lord Mayor for his presence and for permitting the Conference to be held at the Mansion House, and to the Chairman and speakers, was moved by Mr. W. Joynson Hicks, M.P. (Chairman of the London "Safety First" Council), seconded by Sir Edward Smith, J.P., L.C.C. (Vice-Chairman of the London "Safety First" Council), and carried unanimously, and this terminated the proceedings.

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## BRITISH SCIENTIFIC PRODUCTS EXHIBITION.

The British Science Guild, with the assent of the Ministry of Munitions and the approval of the Board of Trade, is arranging for an Exhibition to be held at King's College, London, for four weeks during August and September next.

The Exhibition will be devoted to scientific products which were formerly imported, but are now made in this country; products in the manufacture of which this country especially excelled even before the war; and products in the manufacture of which considerable developments have taken place since the war.

The general scope of the Exhibition includes: Chemical products and processes; physical appliances; electrical and electro-medical appliances; optical apparatus; glass, quartz, refractories, and porcelain; photographic apparatus and materials; measuring instruments and mechanical instruments; surgical, bacteriological, and pathological appliances; papers and textile specialities; illustration and book production; exploitation of British natural products.

Strong sectional committees have been formed, several members of the Illuminating Engineering Society being appointed to act on the Committee on illumination. The Exhibition is under the patronage of H.M. the King, the President is the Marquess of Crewe, and the Vice-Presidents include the Prime Minister and a number of the chief members of the Government; Professor R. A. Gregory is the Chairman of the Exhibition Organising Committee. Particulars of the Exhibition can be obtained from the Organising Secretary, Mr. F. S. Spiers, 82, Victoria Street, London, S.W.1.

The Exhibition promises to be an interesting one, both in making clear the necessity of scientific research in relation to industry, and in showing the encouraging results that have already been obtained by this means in various directions.

# TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

## SIMPLEX FITTINGS.

The Catalogue of Electric Light Fixtures, issued by **Simplex Conduits, Limited,** being out of print, and the present conditions making it impossible for them to issue a new and more complete one, the Company, for the convenience of their clients, have issued a booklet illustrating a few of their new designs together with some of their better known patterns

"Luxura" Bowl Fitting.

Orders for fittings not actually in stock, must be accompanied with a permit from the Ministry of Munitions. There is, however, quite a demand for the lesser expensive fittings for the offices of the many new munition works and departmental offices.

We also understand that the Company have still a fair stock of pre-war fixtures, and would be pleased to send illustrations and quotations upon request.

The illustration shows a useful type of bowl fitting.

## FITTINGS FOR INDUSTRIAL LIGHTING.

A recent list issued by the **British Thomson-Houston Co., Ltd.,** contains illustrations of a useful series of half watt and other fittings for industrial use. Polar curves and photographs of typical installations are included and the now familiar chart to facilitate planning schemes of lighting. We notice that the B.T.H. inspection lamp, specially useful for illuminating the interiors of shells and other hollow objects during inspection, is also included.

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## MESSRS. SIEMENS BROS. & CO.

### An Important Departure.

On the following two pages we give an account of the important reconstruction proposals announced at the Annual Meeting of the above company.

It will be recalled that in 1917 arrangements were concluded with the Public Trustee for the disposal of German shareholdings, and the new arrangements are intended to ensure the future expansion of the Company in British hands.

The condition of the company appears to be one of increasing prosperity, which will no doubt be assisted by the alliances now being concluded with other electrical concerns.

# SIEMENS BROTHERS AND CO., LTD.

## ORDINARY GENERAL MEETING.

The ordinary General Meeting was held on Tuesday, June 11th, at Winchester House, Old Broad Street, Mr. G. Mure Ritchie, the Chairman, presiding.

The Chairman said that during the past year the Company had adhered to its past policy, and the volume of the business done exceeded that of 1916 by about one-third. The expansion in output occurred principally in insulated wires and cables, ebonite and batteries. In regard to the development of automatic telephony, which the Company foresaw before the War, the advantages of eliminating the human exchange operator had been demonstrated in practice and all technical difficulties surmounted, and they were equipped to provide large exchanges for public service, and also private exchanges of 25 to 500 lines. Notwithstanding the demands of War-work, they had completed a semi-automatic exchange of 1,000 lines at Port Adelaide for the Commonwealth of Australia, and a full automatic exchange of 1,300 lines at Grimsby for the G.P.O., while good progress had been made with a full automatic exchange of 950 lines for Stockport, also for the G.P.O. Many private exchanges had been established in Munitions Factories, and had given every satisfaction.

After speaking of the cordial relations existing between the Company and the workpeople, the Chairman went on to say that the year's profit of £208,524 showed substantial increase over that of 1916, due to the very much larger volume of business done. An interim dividend of 10%, free of Income Tax, had been paid, but no further distribution for the year 1917 could be considered until the Government claim for excess profits duty had been adjusted.

The Balance Sheet showed £764,524 for materials, manufactured goods, and work in hand. This was more than double the pre-War amount of £377,385, the increase being due entirely to the growth of expenditure on orders in hand, which at 31st December exceeded in value £1,500,000.

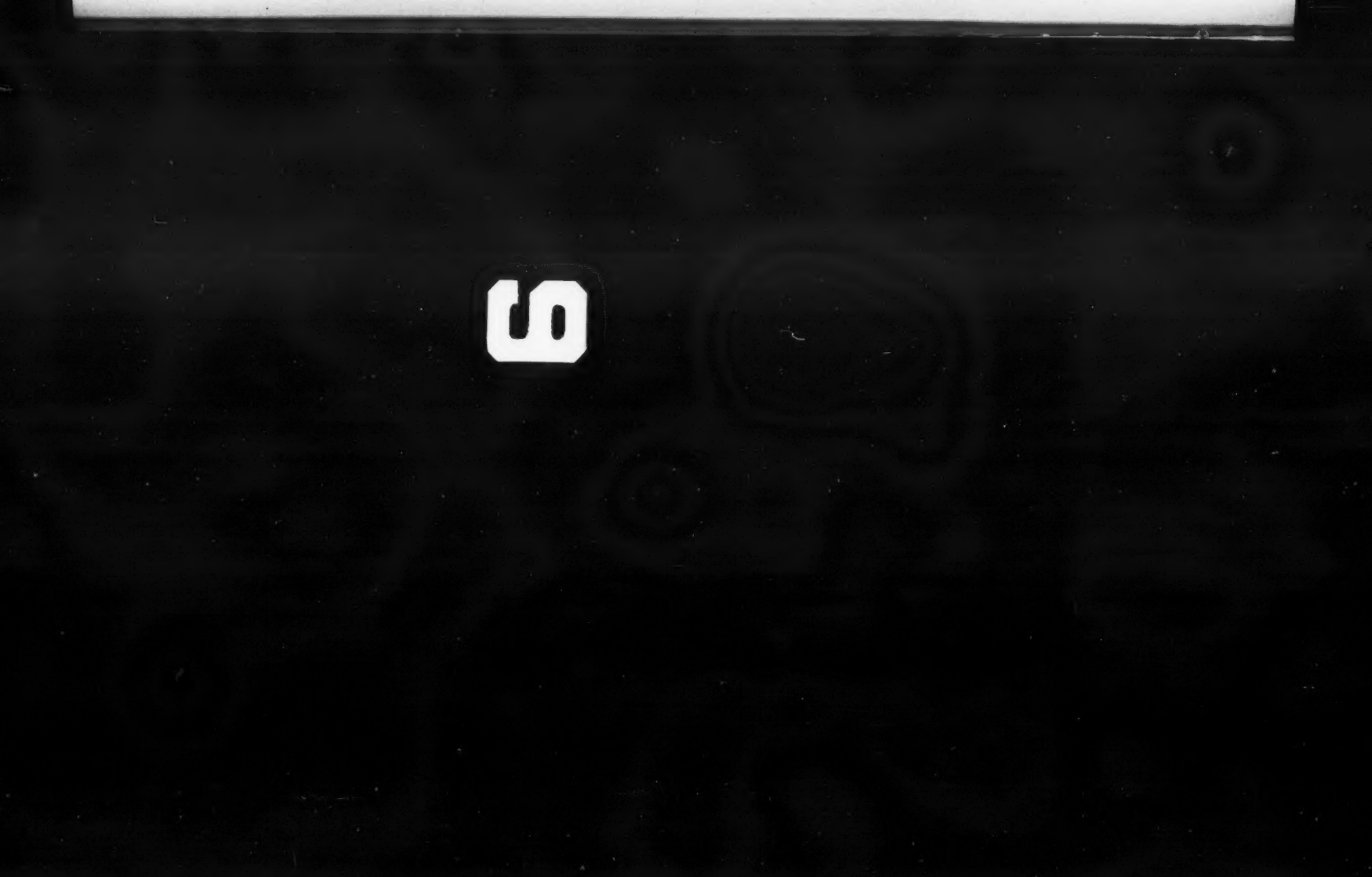
An important asset was the holding of the entire issued capital of Siemens Bros. Dynamo Works, Ltd., namely, £200,000 in shares and £200,000 in Debentures. At the outbreak of War the share capital of Siemens Bros. and Co., Ltd., was £600,000 with £150,000 of 4% Debentures, nearly all the shares and about one-third of the Debentures being held by Germans. Moreover, the German shareholders had supplied funds to meet the capital requirements of the growing businesses of the two companies. When War began, the entire German interest in the shares and the additional capital referred to was vested in the Public Trustee, who took steps to realise it by sale to a British buyer, and on 14th December, 1917, the share capital of Siemens Bros. and Co. was purchased by Messrs. C. B. Crisp and Co. The contract provided for the issue to the Public Trustee by the Comnany of £1,330,000 of 4½% Debentures to provide for the repayment of capital (other than share capital), and the participation in the 4% Debentures employed in the business by the former German owners; and the Public Trustee had a right after the conclusion of peace to call for the redemption of these Debentures on one year's notice. Subject to such arrange-

ment, they were redeemable by annual drawings calculated to extinguish the whole in 25 years from the date of issue.

Following this arrangement with the Public Trustee the Board was re-constituted, and now consisted of Mr. G. Mure Ritchie (Chairman), Sir William Bull, M.P., Sir Clifford Cory, M.P., Lord Queenborough, Mr. H. J. Thomas and Mr. G. Chauvin (Managing Director). The new Board had devoted attention to many questions concerned with the development of Siemens Bros. into a great national manufacturing asset, leaving little time for discussion of a scheme of re-arrangement of the share capital. The Board, however, recognised the advisability of changing the capital arrangements so as to establish equilibrium between share capital and debenture debt, and at an early date the shareholders might be asked to approve a scheme for increasing the share capital to £1,500,000 (or even more) in £1 shares, of which a substantial portion would remain in reserve for future developments; but as to £400,000, if issued for cash, the proceeds would be available for the retirement of a corresponding amount of Debentures. If the matter were carried through on the lines thus indicated, the joint concerns—Siemens Bros. and Co., and Siemens Dynamo Works—would be represented by an issued share capital of £1,000,000, with £150,000 of 4% Debentures and about £1,000,000 of 4½% Debentures, the latter being held by the Public Trustee. These re-adjustments were all subject to the consent of the Authorities concerned, but he could go so far as to say that, as the Board of Trade wished the Company to be so assisted as to ensure its future expansion in British hands, they were justified in believing that sympathetic consideration would be given by the Authorities to their proposals for the financial re-construction of the Company when they were put forward.

Dealing with Siemens Bros. Dynamo Works, Ltd., entirely owned by Siemens Bros. and Co., the Chairman said that the turnover in 1917 increased in the United Kingdom and decreased overseas, as compared with 1916. The value of unexecuted orders on 31st December was £1,145,000. Siemens Bros. and Co. and the Dynamo Works had purchased £50,000 of War Loan, and had provided several thousands of pounds to give temporary assistance to War Savings Associations for the work people.

Since the entry of the new directors into office, negotiations had been inaugurated with other companies doing similar industrial business with the object of bringing such manufacturers together for the reduction of unnecessary competition and the avoidance of duplicating machinery, workshops and offices. Co-operation would make for the more continuous running of plants with the attendant advantages of cheaper production, increased efficiency and improved quality of the work done, avoiding unnecessary expense in storage, selling organisations, and reducing the duplication of stocks to a minimum. An even more important advantage aimed at was the amalgamation of designing offices and interchange of experience, designs and methods to the promotion of economy and efficiency. Such industrial alliance would, moreover, make it possible to carry out complete installations within the Allied group. An alliance of this nature had already been arranged with Messrs. Dick Kerr and Co., Ltd., in the field of dynamo installations in all its ramifications, and other alliances were contemplated. He moved the adoption of the report and accounts, and the motion was unanimously carried. A vote of thanks to the Chairman concluded the proceedings.



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# EDITORIAL.

### The Household Fuel and Lighting Order.

In this issue we give a summary of the Household Fuel and Lighting Order (pp. 153-156) which follows the lines anticipated in our last number.

The Order is a necessarily comprehensive document in view of the many varied aspects which require detailed explanation. Briefly it allows consumers in dwelling houses a fixed fuel ration, and a supplementary allowance of gas or electricity for lighting, according to the number of rooms occupied, within certain limits. The consumer is at liberty to take this fuel ration, partly in the form of coal and partly in the form of gas or electricity, 1 ton of coal being regarded as equivalent to 15,000 cubic feet of gas or 800 k.w.-hrs. of electricity. The fuel allowance is based on two scales, A and B applying respectively to the northern counties and Wales, and to the southern counties and the Metropolitan Fuel Area.

While there are naturally many points in the Order which deserve attention the section of greatest interest to readers of this journal is that dealing with illumination. The lighting allowance varies considerably according to the number of rooms. Thus a person using 1, 2 or 3 rooms

is allowed 7,500 cubic feet of gas and 120 units of electricity, while, at the other end of the scale, a person occupying 19, 20 or 21 rooms is entitled to 30,000 cubic feet of gas and 480 units of electricity. Speaking generally, the Order thus bears gently on the small householder, but demands stricter economies from persons with large houses.

The lighting allowance, though requiring the exercise of considerable economy, is not ungenerous when it is understood that only a few of the rooms specified will be in constant use. Moreover a consumer who finds it difficult to keep within his lighting allowance can supplement it by converting part of his fuel ration into gas or electricity, on the equivalent basis set out above, the only stipulation being that the conversion is made to the nearest quarter of a ton.

There has been some discussion on the relative amounts of gas and electricity specified in the lighting allowance, but we have reason to believe that this matter was most carefully gone into by the authorities, who have made special efforts to provide an impartial and just solution. Some gas engineers have urged that the allowance for electricity is unduly liberal. Some electrical engineers, on the assumptions that 1 cubic foot of gas (low pressure incandescent mantles) yields 20 c.p.-hours, and that 1 unit of electricity (ordinary tungsten lamps) yields about 1,000 c.p.-hours, find that, *on the basis of light for light* the comparison is not particularly advantageous to users of electricity. The Order regards 750 cubic feet of gas giving on the above basis 15,000 c.p.-hours as equivalent to 12 units of electricity giving only 12,000 c.p.-hours. Assuming, therefore, that the object of the allowance is to provide the same amount of light in each case the consumer who uses gas-lighting would, on this basis, be at an advantage. It is argued that to demand a diminution in the electricity ration is to underestimate the efficiency of the average gas lighting.

We have dwelt upon this point because it seems to us that the principle on which the allowances for lighting are related should be the provision of equal illumination.

The Order as presented applies primarily to dwelling houses, but we understand that special provision has been made to meet the requirements of schools, factories, hospitals, theatres, etc., without imposing undue hardship. In regard to offices and workshops due consideration will be given to the nature of work carried on (*e.g.*, whether involving rough operations or fine detail work) in fixing the amount of illumination required. In all such cases gas and electric supply companies are also presented with a unique opportunity of making themselves very useful to consumers by discharging the patriotic duty of impressing on them the most judicious measures of economy, including the selection of efficient lamps and lighting appliances and the adoption of systematic measures for keeping them in good cleanly condition.

We observe that a large number of experts have offered their services to the Coal Controller with a view to affording guidance as to how economies can best be made in the use of coal; their assistance may be obtained by application to the Coal Controller's Headquarters (Holborn Viaduct Hotel, London, E.C.). On our part we propose in our next number to show, by typical examples, how requirements as regards illumination can best be met.

# MAINTENANCE OF LIGHTING INSTALLATIONS AND ECONOMY IN LIGHTING.

We have previously referred to the extra importance of lighting maintenance, in view of the present need for economy in illumination. When one considers the combined effect of dirty lamps and reflectors, lamps which have deteriorated through being used too long, and neglect to renew broken reflectors on certain units, we find that such an installation may quite probably give only 50 per cent. of the illumination which ought to exist on the working plane. The maintenance of electric motors is quite a common practice. In the case of gas lighting also, regular maintenance by the companies is now an established practice the value of which has been demonstrated again and again. In the case of electric lighting the absence of any regular machinery for overhauling and maintaining lighting installations seems an omission that should be remedied. In the present circumstances the effect of such maintenance in many cases would be to enable consumers to get the same illumination as they at present derive from their imperfect lighting arrangements with an expenditure of electrical energy much less than that used at present.

Our attention is drawn to this subject by a recent paper by Mr. D. H. Tuck, who is associated with the United States Public Health Service. Mr. Tuck mentions as the chief factors in causing deterioration of lighting equipment: (1) Diminution in candle-power of lamps owing to use for an excessive period; (2) accumulations of dust and dirt on lamps and reflectors; (3) burning out of lamps and breakage, lamps not being replaced; (4) cracked, broken or missing reflectors; (5) mechanical injury to connections. He estimated that most of these defects will in practice lead to only 70 to 80 per cent. of full lighting efficiency being obtained, while neglect to replace broken reflectors may at once diminish the useful component of the light produced—*i.e.*, on the working plane—by 50 per cent. As an instance he takes a shop in which the thirty lighting units inspected were all more or less faulty. In twenty-one cases lamps and reflectors were dirty, and in two cases the lamps also very much blackened through age, while in four cases reflectors were missing. It was estimated that the efficiency of maintenance of this installation was only about 55 per cent., and it was actually proved, by measurements with an illumination-photometer, that the average working illumination could be doubled when the various defects were made good.

Another instructive case, this time indirect lighting, was mentioned by Mr. Ward Harrison in a recent contribution to the *Electrical World*. In an indirect installation we have also to take account of the diminution in illumination due to walls and ceilings becoming discoloured with age. The equipment was improved by stages, measurements of illumination being made at each step with the following results:

| | Illumination (foot-candles). |
|---|---|
| Before making any improvements ..... | 3.75 |
| After cleaning reflectors ..... | 4.68 |
| After also substituting new lamps ..... | 5.26 |
| After also repainting ceiling ..... | 6.75 |

The total effect was to increase the illumination by about 80 per cent., and it is notable that merely wiping out the reflectors alone produced a 25 per cent. increase. These figures illustrate the need for effective maintenance of lighting installations—a matter which deserves special attention from the illuminating engineer at the present time.

# ELECTRICAL INCANDESCENT LAMPS FOR CINEMATOGRAPH WORK.

Ever since the introduction of the gas-filled lamps attempts have been made to apply this source to cinematograph projection, and, according to a recent contribution to the *General Electric Review* (U.S.A.) by Mr. L. C. Porter, with which we deal in this issue (pp. 157-158) some promising results in this field have recently been secured. Further particulars of the method involved are given in a late paper in the *Transactions* of the Illuminating Engineering Society (U.S.A.), by Messrs. J. T. Caldwell, A. R. Dennington, J. A. Orange, and L. C. Porter.

The difficulties involved in the use of filament lamps for projection appear to have been largely overcome by (*a*) the use of a specially designed, compact and stout filament operated at a very high efficiency (and a corresponding life of about 100 hours); (*b*) the use of a special form of condenser-lens which allows the filament to be brought near and envelops a much larger proportion of the light-flux than hitherto; (*c*) the judicious use of a mirror, which superimposes an image of the filament so as to fill up the interstices between individual bars, giving an approximately uniform source.

It is, of course, too early to speak with certainty as to the applications of this new apparatus, but the method of attacking the problem is ingenious, and the results so far obtained appear hopeful. Provided that the requisite screen-illumination can be secured, a filament has several decided advantages over an arc. The flicker is eliminated, the noise attending the use of alternating arcs is avoided, and the heat developed is much less. There is thus, it is claimed, less danger of cracked condensers, and the manipulation of the light-sources by the operator is very much more simple than in the case of an arc. One point that is clearly important is the avoidance of possible interruption of the performance through failure of the filament. This, however, has been borne in mind, an apparatus being provided which enables a new lamp to be immediately inserted in the circuit in the event of a filament failing. The authors consider that the incandescent lamp has decided advantages over an alternating system; with a direct-current system the advantage, as compared with an arc light, is less.

Obviously the field for such a device, if successful, is very great. There are said to be at least 22,000 picture-theatres in the United States, apart from colleges, schools, etc., which have frequently special equipments; and it is estimated that 80 per cent. of these theatres could use incandescent lamps. It is further computed that, by replacing the arcs in all the theatres, a large amount of coal could be saved annually—a matter of some consequence at the present moment.

In the Appendix to the paper read before the American Illuminating Engineering Society, some interesting data for screens, of magnesium oxide, aluminium bronze and mirror type, are given. The use of these special screens, which yield a considerable proportion of direct reflection, is limited by the nature of the area to be occupied by spectators, and we believe that in this country the use of a good dead-white screen material is more usual. It is worth noting that, according to the authors' experience, frequent cleaning of the screen is very important, as deposits of dust may reduce the brightness by quite 50 per cent.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

*The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.*

# THE LIGHTING, HEATING AND POWER ORDER (1918) AND THE BEST METHODS OF MAKING ECONOMIES.

(Discussion following the Annual Meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W., at 6.30 p.m., on Tuesday, May 14th, 1918).

*(Concluded from p. 138, May, 1918.)*

MR. J. S. DOW exhibited several typical electric incandescent lamps, which the British Thomson-Houston Co. had kindly arranged for the meeting, showing the great difference in the amount of light received for a given amount of coal, converted into electricity, when carbon filament lamps were replaced by metal filament ones. Thus both a 16 c.p. carbon filament lamp and a 60 watt metal filament lamp would use in an hour an amount of electricity equivalent to about 3 ozs. of coal consumed; but the light available in the latter case was more than three times as great. Assuming that a ton of coal would produce 800 units of electricity, it was apparent that with carbon filament lamps the ton of coal would yield about 200,000 c.p.-hours, with vacuum metal filament lamps about 650,000 c.p.-hours, and with gas-filled or "half-watt" lamps about 1,000,000 c.p.-hours.

MR. T. M. TYE (*communicated*):

The reduction in the consumption of gas or electricity for lighting, made necessary by the new Order, demands close attention in arranging lighting equipments. In determining the reduction care must be taken that the resultant illumination does not fall below the minimum prescribed as essential for carrying on the particular class of work; otherwise, the speed of production may be diminished. This applies mainly to factories and workshops. In arranging lighting installations with a view to economy, it should be the aim to use the most efficient light-source available, and if the number of points is diminished it should be remembered that the light distribution yielded by the remaining points requires modification, otherwise the illumination will be no longer uniform. In such cases it is most important to ensure that reflectors of the highest efficiency, giving distri-

bution curves adapted to the spacing and height of units, are employed. Great advantage is also to be derived from the frequent cleaning of the light-sources and accessories—a matter that is apt to be overlooked. Whilst no doubt the Order will make necessary economies in the lighting field, it is evident that the field deserving closest attention from the Authorities, in making economies, is the domestic fuel consumption.

MR. G. C. WESTON, Kensington and Knightsbridge Electric Lighting Co., Ltd. (*communicated*):

In addition to the points raised in Mr. Gaster's interesting introduction, there are several that might be considered. Whatever the Supply Authorities may think of this Order, it is now in force and has to be administered with all the various difficulties its operation involves; it is hoped it may be found expedient to amend some of these at a later date. Whilst it is common knowledge that one-sixth of the amount of fuel consumed for the supply of light within the area to which this Order applies will be a very small percentage of that used for other purposes, it is, I presume, chiefly with the application of this that your Society is interested; moreover, it affects by far the largest number of consumers, these being considerably in excess of those who use energy for heating and power purposes. As one of the engineers of a London company supplying electricity, I have had to deal with a large number of instances arising out of the application of this Order, and should like to put forward a few practical points, the result, so far, of this experience.

Whilst fully agreeing with the suggestions made in your paper concerning the advice that should be given to consumers with regard to the proper use of illuminants and the best methods of effecting economies, a practice your Society has set out to foster, it is the practical application of these that is likely to cause difficulties. How is it going to be done? The issue of a list of recommendations to consumers may be of value, but it is obvious that each case requires almost individual treatment, and in these times this is an impossibility. The Order is now in force, Supply Authorities are overwhelmed with thousands of enquiries, everyone wanting his case settled at once, and, with the staffs available, and considering that all this is additional work, it is almost impossible to take advantage of this opportunity of advising on the best means of economising or using light in each individual case. The question of assessing the consumption also raises many difficult points. Estimating the amount from that recorded on premises used for similar purposes in the neighbourhood is not so easy as it appears on paper, and involves considerable work. Those accustomed to this kind of work know the very great variation in the use of light that is found when similar premises are compared; it is often very difficult to arrive at a proper average by this process. An easier and probably a fairer way is to take the average consumption per 30 watt lamp per annum for the whole of the district for a certain class of lighting and assess the quantity from this; it is obvious that the average of recent years or since the "Summer Time" Order was in force must be used. The usual percentage of the consumption per quarter can then be obtained from this. Whilst a number of users have already economised in the use of light to a considerable extent and will experience difficulty and inconvenience in meeting the terms of this Order, it should be an easy matter for the majority to effect the required saving. In this connection it would be as well to point out that a considerable waste of light often occurs in the servants' quarters. Where the Supply Company has a lower rate per unit for basement lighting it is possible to ascertain how often the consumption in these quarters is in excess of the actual requirements. Finally, certain premises exempted from the application of this Order, so far as lighting is concerned, would, in many instances, stand as excellent examples of the misuse and waste of light, and might, with advantage to all concerned, have been included.

# THE HOUSEHOLD FUEL AND LIGHTING ORDER (1918).

It will be recalled that in our last issue we published a memorandum presented at a meeting at the Institute of Journalists on June 7, summarising the aims and objects of the above Order. The full text of the Order has now appeared in the *London Gazette* for July 2, and in what follows we give a summary of the chief points of interest from the lighting standpoint:

PART 1.—THE SCOPE OF THE ORDER.

1. This Order extends to coal, gas and electricity used for heating or cooking or for any other than industrial purposes, exclusive of lighting, and to gas and electricity used for lighting purposes in connection with any house, building or other premises in respect of which the provisions of this Order apply. It extends to coal, gas, and electricity used for industrial purposes where such industry, trade or business is carried on in a dwelling house or other building used in connection with a dwelling house. It extends to coal used for the generation or production of gas or electricity in a private works, for consumption in a house, building or other premises in respect of which the provisions of this Order as to fuel apply. It extends to coal, gas and electricity used in laundries, bakehouses, dairies, greenhouses and other industrial or trade premises carrying on occupations or businesses of a domestic or quasi-domestic character. It extends to coal, gas and electricity used in any premises for industrial purposes where the total quantity to be used in any year shall not exceed 100 tons. In case of dispute as to whether any such premises come within the scope of this clause, the decision of the Controller of Coal Mines shall be final.

2. In this Order "Coal" means anthracite and all other kinds of fuel of which coal or coke is a constituent; "Fuel" means coal, gas and electricity used for all purposes except lighting coming within the scope of this Order.

3. The Controller of Coal Mines for the time being appointed by the Board of Trade, hereinafter referred to as the "Controller," shall be responsible to and is hereby authorised by the Board of Trade to exercise all the powers belonging to the Board of Trade in relation to the subject matter of this Order.

4. The Controller may suspend from time to time and for any period, and in any district of a Local Authority, the operation of any of the provisions of this Order as he may think fit, and may in like manner restore such operation.

5. This Order applies to England and Wales and throughout this Order "Month" means a calendar month; "Quarter" means a three-monthly period ending as nearly as possible on the 31st March, the 30th June, the 30th September or the 31st December in any year.

PART II.—ALLOWANCES FOR FUEL AND LIGHTING.

6. Subject to the provisions of this Order the allowances of fuel in respect of any dwelling house or part thereof, or flat or tenement in separate occupation, shall not exceed the quantity prescribed in accordance with the following table, or such other quantity, whether less or more, as the Controller may subsequently determine, for any period of time or in respect of any district:—

| Where the number of rooms occupied is - | The fuel allowance for the year shall not exceed— | | | |
|---|---|---|---|---|
| | A. | | B. | |
| | Tons. | Cwts. | Tons. | Cwts. |
| Not more than 2... | 3 | 10 | 3 | 0 |
| 3 ... ... ... | 4 | 0 | 3 | 10 |
| 4 ... ... ... | 4 | 10 | 4 | 0 |
| 5 ... ... ... | 5 | 0 | 4 | 10 |
| 6 ... ... ... | 6 | 0 | 5 | 0 |
| 7 ... ... ... | 7 | 0 | 6 | 0 |
| 8 ... ... ... | 8 | 0 | 7 | 0 |
| 9 ... ... ... | 9 | 0 | 8 | 0 |
| 10 ... ... ... | 10 | 0 | 9 | 0 |
| 11 ... ... ... | 11 | 0 | 10 | 0 |
| 12 ... ... ... | 12 | 0 | 11 | 0 |

and for every additional room 1 ton until a maximum of 20 tons is reached, thereafter any additional allowance not exceeding 1 ton per room shall be in the discretion of the Local Fuel Overseer.

Provided always that where the number of people habitually resident in a flat or tenement or dwelling house or part thereof in separate occupation of not more than 12 rooms exceeds 6, the scale allowance as determined by the above table shall be increased by 1 ton.

The two scales indicated in the tables shall apply as follows:—

(*a*) To the counties of—
Cheshire, Cumberland, Derbyshire, Durham, Herefordshire, Lancashire, Leicestershire, Lincolnshire, Monmouthshire, Northumberland, Nottinghamshire, Rutlandshire, Shropshire, Staffordshire, Warwickshire, Westmorland, Worcestershire, and Yorkshire, in England; and

To Wales.

(*b*) To the counties of—
Bedfordshire, Berkshire, Buckinghamshire, Cambridgeshire (including the island of Ely), Cornwall and the Isles of Scilly, Devonshire, Dorsetshire, Essex, Gloucestershire, Hampshire and the Isle of Wight, Hertfordshire, Huntingdonshire, Kent, Norfolk, Northamptonshire (including the Soke of Peterborough), Oxfordshire, Somersetshire, Surrey, Suffolk, Sussex, and Wiltshire, in England;
To the Metropolitan Fuel Area as specially defined; (see clause 124).

7. Consumers may take the allowance of fuel to which they are entitled under the table either in coal, gas, and/or electricity at their option, in accordance with the following rules :—

In calculating the prescribed quantity :

(*a*) Anthracite shall count as fuel at the same rate as ordinary coal.

(*b*) 3 tons of coke shall only count as 2 tons of fuel, and so in proportion for other quantities.

(*c*) Briquettes not sold by weight and not exceeding 2½lbs. each in weight shall count as 1,000 to the ton and so in proportion.

(*d*) 15,000 cubic feet of gas shall count as 1 ton of fuel.

(*e*) 800 Board of Trade units of electricity shall count as 1 ton of fuel.

The quantity of fuel to be taken as gas or electricity must be calculated to the nearest quarter of a ton.

The allowance of fuel to be taken as coal shall not be less in any case than 2 tons 10 cwts., except with the previous assent of the Local Fuel Overseer.

Any quantity of fuel allowed additional to 20 tons may be required to be taken either wholly or partly as coke.

The Controller may by notice alter the conversion equivalents set out in this clause either by increase or decrease at any time and for any district. . . .

8. In addition to the allowances for fuel as set out in clause 6, there shall be allowed for lighting the quantities of gas and/or electricity prescribed in accordance with the following table, or such other quantities, as the Controller my subsequently determine :—

| Where the number of rooms occupied is— | The lighting allowance for the year shall not exceed— | |
|---|---|---|
| | either cubic feet of gas | or B. of T. units of electricity. |
| 1, 2 or 3 ... ... | 7,500 | 120 |
| 4, 5 or 6 ... .. | 11,250 | 180 |
| 7, 8 or 9 ... ... | 15,000 | 240 |
| 10, 11 or 12 ... | 18,750 | 300 |
| 13, 14 or 15 ... | 22,500 | 360 |
| 16, 17 or 18 .. | 26,250 | 420 |
| 19, 20 or 21 ... | 30,000 | 480 |

Gas or electricity allowed for lighting under this clause may at the option of the consumer be used for other domestic purposes, but cannot be converted into coal.

Where gas and electricity are both used for lighting the consumer may elect to take under this clause part of the allowance as gas and part as electricity, 750 cubic feet of gas being taken for this purpose as equivalent to 12 B. of T. units of electricity, and *vice versa*. Conversion may only take place by multiples of these quantities.

9. Rooms shall only count where furnished and in actual occupation, except that bedrooms furnished but only occasionally occupied shall count as rooms. The following shall not count as rooms, viz. : Sculleries, bathrooms, halls not used as sitting rooms, dressing rooms not used as bedrooms, boxrooms, cellars, pantries not containing fireplaces or stoves, storerooms, greenhouses attached to houses and outbuildings. There shall not be any allowance in respect of a dwelling house or part thereof or flat or tenement which is permanently unoccupied. . . .

Where a consumer has more than one place of residence the allowances or assessments of his several places of residence shall be considered as a whole in relation to the actual occupation thereof.

10. Not more than one-third of the total allowance of gas and/or electricity, under clauses 6, 7 and 8 hereof may be taken in any one quarter of the year, subject to such reasonable adjustment as may be necessary. . .

11. Additional allowances not exceeding 5 tons of fuel in a year in respect of each separate household may be granted by the Local Fuel Overseer on the application of the householder, where the absence of an additional fire or additional heating or cooking or lighting is shown to cause material hardship, on all or any of the following grounds :—

(1) The presence of aged or infirm persons, invalids, or young children. (2) The occupation of separate rooms by lodgers. (3) The use of rooms for a business or profession in a dwelling house or other building used in connection therewith. (4) The necessity for the upkeep of fires and light during the night as well as the day by reason of the hours during which the householder or other resident is engaged at work. (5) Illness, but in this case the allowances shall be of temporary character only in accordance with a medical certificate to be provided by the applicant.

An additional allowance shall be in fuel or in such specific fuel as coal, coke, gas or electricity as the Local Fuel Overseer may determine. An additional allowance or part thereof may be used for lighting.

An additional allowance may in the discretion of the Local Fuel Overseer be made contingent upon the existence of surplus supplies of coal, coke or other fuel in any month.

Further additional allowances not exceeding 5 tons of fuel in a year may be granted on the

application of the householder where the supply is required for actual consumption in connection with any industrial trade or manufacturing process carried on in a dwelling house or other building used in connection with a dwelling house, such allowances to be distinct from the allowances (if any) granted for the reasons stated in the preceding part of this clause.

12. (*a*) The occupier of a dwelling house or part thereof or flat or tenement exceeding 15 rooms as defined above; or

(*b*) The occupier of any building not used or only partly used as a dwelling house

may apply to the Local Fuel Overseer for the district in which the premises are situated to be assessed individually, having regard to his special requirements in the way of heating, cooking, lighting, or other services, the extent and nature of his buildings, the purposes for which he consumes fuel and lighting, his previous consumption within one or more of the three years prior to the 1st July, 1918, and any other special circumstances, and the amount of such assessment shall be the maximum quantity to be allowed in respect of such premises either for fuel under clause 6 hereof or for lighting under clause 8 hereof, as the case may be. . . .

The Controller may direct that any applications or certain classes of applications under this clause be referred to him for assessment in the first instance.

13. Single assessments of fuel and/or lighting supplies shall on request of any consumer or if required by the Local Fuel Overseer be made—

(*a*) for a residential estate or farm where the proprietor, occupier or manager supplies fuel and/or lighting to his tenants, servants and workpeople.

(*b*) for a block of flats or tenements where the proprietor or manager undertakes wholly or partly the supply of lighting or heating or the provision of hot water or other services involving the consumption of fuel.

(*c*) for a group of houses, cottages or rooms managed on a communal basis.

(*d*) for a dwelling house occupied by more than one household in common.

(*e*) for a dwelling house part of which is occupied by a sub-tenant, but such part is not separately assessed for rating purposes.

Such assessment shall have regard to any previous practice with regard to the supply or distribution of fuel and/or lighting and in the discretion of the Local Fuel Overseer or the Controller shall be either a total quantity calculated in respect of each separate household in accordance with the tables in clause 6 and 8 hereof, or by special assessment in accordance with the provisions of clause 12 hereof. . . .

14. Where fuel is required for the generation or production of gas and/or electricity, not for public sale and distribution, but for consumption in a house, building or other premises in respect of which the provisions of this Order as to fuel apply, the allowance of fuel to be made for such purpose shall be limited to the amount actually required for the generation or production of the quantities of gas and/or electricity to which such house, building or other premises is entitled under the provisions of clauses 6 to 13 hereof inclusive.

15. Where fuel is allowed under an assessment for a specific purpose it shall not be applied to any other purpose without the previous assent of the Local Fuel Overseer.

Fuel required for industrial purposes not within the scope of this Order may be purchased or acquired with household fuel, and in addition thereto, upon the declaration of the consumer as to the industrial purposes for which it is required and the production of the proper authority.

16. Allowances and assessments shall run for one year calculated from the first day of July, or from such approximate date, being the date of the last meter readings in the case of gas and electricity, or for such part of such year as there may still be to run at the date of the requisition or assessment, in which latter case the quantity allowed or assessed shall be adjusted as provided in clause 9 hereof; or in the alternative allowances and assessments shall run for one year from the date of the requisition.

Except that where it is known or there is reason to suppose that an occupation is only temporary, allowances and assessments shall be for one or more months in the discretion of the Local Fuel Overseer, and shall be renewed from time to time. . . .

17. There shall be an appeal from the decision of the Local Fuel Overseer, upon any allowance or assessment under clauses 6 to 14 hereof inclusive, in the first instance to the Local Fuel and Lighting Committee hereinafter referred to, and in the second instance to the Controller. The decision of the Controller shall be final in every case.

18. Coal supplied to miners and other regular workers at collieries or in connection therewith, either directly or indirectly, and whether free or at a nominal or reduced price, in accordance with any agreement or with any previously established practice relating to wages' payments or in substitution therefor, shall be continued and shall not be reduced by reason of any of the provisions of clauses 6 to 14 hereof, inclusive; nor shall any form of requisition or other application be required from miners and such other persons entitled to such supplies.

PART III. sets out in detail the steps to be taken in forming Local Fuel and Lighting Committees, Local Fuel Overseers, &c. Local Fuel and Lighting Committees shall be constituted as follows:—

One member elected or nominated by coal merchants in the district; one mem-

ber nominated or elected by persons licensed as coal dealers; one member nominated by the local electricity concern; one member nominated by the local gas company: and if the Controller or Local Authority desire three members nominated respectively by railway companies, canal companies, or harbour board or company operating in the district. In any case, an equal number of members to those already specified are to be appointed by the Local Authority.

PART IV. deals with the Registration and Licensing of Coal Distribution Agencies.

PART V. is devoted to Procedure. After 42 days from the date of the Order no person may acquire fuel or lighting except in accordance with the terms of the Order. Every person requiring coal not exceeding 1 cwt. at one time, up to 2 tons 12 cwts. in any period of 12 months, and gas not exceeding 7,500 cubic feet, in any one quarter, or 225,000 cubic feet in 12 months, and electricity not exceeding 40 B.O.T. units in any quarter or 120 B.O.T. units in 12 months, may be required to state the name and address of the registered coal merchant from whom he proposes to purchase. Any consumer desiring to be supplied with fuel exceeding these set out in clause 51 must obtain and fill up an application to be addressed to the registered coal merchant, by whom it will be brought before the Local Fuel Overseer. Application forms will be obtainable at any registered coal merchant's offices. All applications for fuel and lighting are to be sent to the Local Fuel Overseer within 12 weeks from the date of the Order coming into effect. Within seven days of the receipt of the application the Local Fuel Overseer will issue requisitions for fuel and lighting.

The remainder of this section deals mainly with the procedure to be adopted in dealing with consumers' requirements.

PART VI. sets out in detail the duties of consumers, which, however, will be generally understood from the foregoing sections.

PART VII. summarises the Duties of Coal Merchants and Dealers.

PART VIII. the Duties of Undertakers of Gas and Electricity Supplies, who are to keep such records of their supplies to all consumers as the Controller may require and furnish returns to the Local Fuel Overseer or the Controller. Meter-readings are to be taken every quarter, and returns made within six weeks after the close of any quarter.

PART IX. deals with the Sale of Coal.

PART X. covers Enforcement and Penalties. Failure to comply with the terms of the Order is an offence under the Defence of the Realm Regulations. In cases where consumers have taken an excess of gas or electricity, the corresponding amount of coal to the excess may be deducted from future allowances.

PART XI. contains special clauses applying to the Metropolitan Fuel Area.

PART XII. covers Miscellaneous Items.

The Order may be cited as the "Household Fuel and Lighting Order, 1918," and is issued by the Board of Trade, 7, Whitehall Gardens, London, S.W. 1, and dated June 28th, 1918.

## FURTHER DIMINUTION IN STREET LIGHTING IN LONDON.

We understand that the Chief Commissioner of Police has written to the Metropolitan Borough Councils stating that the authorities have agreed to a further diminution in street-lighting to the extent of 50 per cent. of pre-war lighting, as an experimental measure to effect economy in the consumption of coal.

It is stipulated, however, that the reduction is to be spread equally over both main and side streets. Special importance is attached by the military to a uniform lighting effect, and it is not desirable that main roads should be easily distinguishable from side streets.

Furthermore the measure is subject to revision should it be found that the reduced lighting leads to increases in crime or danger to pedestrians or vehicular traffic, or impedes the supervision of the streets by an already depleted police force.

Attention was called to these and other important points in connection with the proposed further diminution in street lighting at the last meeting of the London "Safety First" Council on July 18, when a report from the Street Lighting Sub-Committee on the subject was adopted.

# AN ELECTRIC INCANDESCENT LAMP FOR CINEMATOGRAPH WORK.*

By L. C. Porter.

The steadiness, good colour value, lower fire-risk, and ease of control of the electric incandescent lamp have led to a number of attempts to use such lamps for cinematograph work.

The chief considerations which have led to the use of the arc in preference to incandescent lamps for cinematograph work have been :—

(1) The crater of the arc, as commonly used for such work operates at about 130 c.p. per square mm. ; whereas the tungsten filament emits only about 34 c.p. per square mm.

These obstacles have now been to a large extent overcome by various devices. In the first place it was desirable to increase the angle subtended by the condenser by the source. It was, however, found impracticable to make a plano-condenser of sufficiently short focus, as the thickness of glass and curvature would be excessive, resulting in marked spherical aberration. The difficulty was overcome by the design of a condenser somewhat similar to a semaphor lens, *i.e.*, a one-piece condenser made in steps or corrugations (see Fig. 2). By

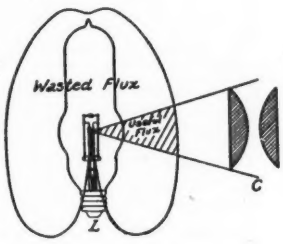


Fig. 1.—Showing how with an ordinary condensor, C, only a small percentage of the total flux of light from an incandescent lamp, L, can be effectively used.

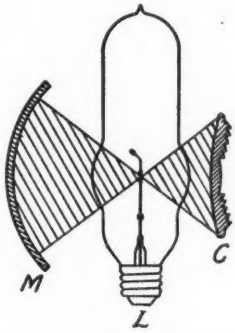


Fig. 2.—By the use of the special condensor, C, placed much nearer to the filament of the lamp, L, and the spherical mirror, M, behind it, a much larger proportion of the total flux is usefully employed.

(2) The condensers in common use subtend at the source a solid angle of light of about 32 degrees. This angle picks up a high percentage of the light distribution of the arc as a rule, whereas, with the comparatively spherical radiation of the incandescent filament (see Fig. 1) only a small portion of the available light emitted falls upon the lens.

(3) The crater of the arc is a relatively homogeneous light source, resulting in fairly even illumination, whereas the enlarged image of the filament of an incandescent lamp may be projected, giving rise to streaky effects.

this means as much as 75 degrees of the light-flux were intercepted. The condenser is $4\frac{7}{16}$ in. diameter. The light is placed $2\frac{1}{2}$ in. away from the convex side and the film $6\frac{1}{2}$ in. ahead of the corrugated side.

A further gain in illumination is achieved by the use of a spherical mirror placed behind the light source which practically doubles the angle utilised, with the result that light is taken from 150 degrees as compared with 32 degrees with the old plano-condensers.

* Abstract of an article in *The General Electric Review* (U.S.A.)

Another step has been the attainment of a still higher intrinsic brilliancy by operating the filaments as near the melting point as practicable, the life then being approximately 100 hours.

The filament consists of four helices of tungsten mounted in a single plane which enables more of the filament to be brought close to the focus of the condenser and causes the spherical mirror to form an image practically co-incident with the actual filament. The proper location of lamp, mirror and lens are thus very important.

The capacity of the lamp finally chosen was 750 watts, operating at 30 amperes and 25 volts. The filament was designed with a view to the fact that the condenser will pick up light from a 0.4 in. square. An accurate ammeter in series with the lamp is essential to regulate the current owing to the high temperature at which the lamp is run. A 600 watt lamp operating at 30 volts and 20 amperes has also been developed and may be readily used in conjunction with the petrol driven generator sets used throughout the country for cinematograph work.

Investigations have also been made with a view to still further increasing the diameter of the objective lens. Objectives in common use for arc lamps are $1\frac{1}{2}$ in. to $1\frac{3}{4}$ in. diameter, but there are also available lenses of $2\frac{1}{2}$ in. diameter, which will give approximately twice the illumination obtainable from a $1\frac{1}{2}$ in. lens, and are specially adapted for use with the new incandescent lamps.

A table is presented in the original paper to show the comparative cost of these special incandescent lamps and arc lamps for cinematograph work. The saving in running cost per 10-hour working period varies from 0.48 to 6.40 dollars (approx. 2s.—£1 6s.) according to circumstances, but is always in favour of the incandescent lamp.

The advantages of the lamp are summarised as follows :—

(1) Great reduction in operating cost.

(2) Better colour and greater steadiness of light.

(3) Reduction in wear and tear of machines and films owing to elimination of ash from carbon arc.

(4) Less heat in the operating booth.

(5) Simpler control.

The 750 watt lamp will replace any alternating current arc on the market, and direct current arcs up to 40 amps., and will project pictures 12 feet wide on white plaster screens or 16 feet pictures on metallic, fibre or glass screens.

## GLOW-LAMPS FOR PROJECTION PURPOSES.

An article by O. Kruh in *Elektrotechnik und Machinenbau* summarises some of the difficulties involved in producing suitable glow lamps, of high intrinsic brilliancy and small luminous area, for optical and projection work.

Recently improvements have been made by mounting tungsten filaments very close together and side by side, within a small space, and by using stout filaments taking a large current. The chief difficulty in designing gas-filled lamps of this type is to attach the leading in wires in a satisfactory air-tight manner. The author states, however, that he has recently overcome this difficulty and that lamps taking up to 200 amps. and giving 30,000—40,000 candles (Hefner) have been constructed; the candle-power attainable from such lamps is limited only by the size of the bulb, and if necessary lamps giving up to 100,000 candles could be made. Owing to the thickness of the filament, and the fact of its being surrounded by gas and being less cooled thereby than a thinner filament, it has been found possible to work such lamps at only 0.25 watts per candle (Hefner).

An additional device described by the author is the use of a mirror behind the lamp, adjusted in such a way that an image of the bar-filaments is projected into position so as to fill completely the gaps between adjacent wires. In this way a substantially uniform source of light is obtained. It is pointed out that by this means the intrinsic brilliancy of the source as a whole is approximately doubled, which would not be the case with an arc-crater. By this means the intrinsic brilliancy of these special "half-watt" lamps can be brought up to about 70 candles (Hefner) per sq. mm., which approaches that of the crater of the carbon arc, as ordinarily used for projection unity of moderase power.

## WOMEN AS ADVISERS ON GAS LIGHTING.

REFERENCE has previously been made in this journal to the value of the services of women in advising consumers regarding their gas and electric lighting. At the Boston Gas Convention in the United States an interesting account was given of the methods pursued at Brockton, U.S.A., whose representatives include a lady, Mrs. Howard, who is stated to have been very successful in assisting consumers in this way.

An account of the experience of the Brockton Gas Co. is contributed by Mr. H. Chas. Wardell to a recent issue of the *Gas Age*. Although the appliances concerned include a form of gas apparatus used by domestic consumers, special importance was attached to the improvement of home illumination by the installation of modern and attractive fixtures. Keen interest in the subject is being expressed in the United States and many of the papers before Gas Conventions deal with this aspect of gas supply, which deserves fuller development.

For example, the annual gas consumption of a standard gas range is put at 12,000 cubic feet. Now, a typical two-mantle fixture consumes about 6 cubic feet per hour. If this is used for four hours a day for ten months the total consumption is 7,200 cubic feet per annum, or 60 per cent. of the amount of gas consumed in the same period by an average gas range. 355 semi-indirect units of this type were sold, thus equivalent to a consumption of about 2,600,000 cubic feet in one year. The writer asks whether 216 gas ranges, consuming this amount could have been placed in the same period with the same effort and expense.

In deciding upon this fixture a careful survey of the conditions in the average home was made. The semi-indirect fitting adopted seemed to meet all requirements, being inexpensive and attractive. No special advertising costs were undertaken and the 355 units sold involved an expenditure of only one-third of the workng time of the six maintenance salesmen concerned.

The Brockton Gas Company claims to be the first to employ women regularly on maintenance-selling work, involving the inspection of all gas-consuming appliances on the premises. Mrs. Howard, the lady representative, appears to have been exceptionally successful, sometimes showing twice the results obtained by the best of the men. She was soon acquainted personally with many of the ladies in the district and was evidently able to enter into domestic problems involving the use of gas with an intimacy which the average salesman does not as a rule enjoy. Tact, sympathetic insight, and an eye that is practical and observing are useful qualifications in a canvasser. Summing up, the writer remarks: "Experience seems to demonstrate that the best domestic maintenance of the future will be rendered by women."

Canvassers and maintenance inspectors should adopt the attitude of one who is glad to offer suggestions, rather than that of a salesman seeking orders. They thus render a service to the consumer throughout the interview, both by improving appliances and supplying information. A woman, moreover, more easily gains access to the home. "A housewife looks upon a man in overalls as a bull in a china shop, and is correspondingly nervous when he is about." Since rendering service is the main duty of a representative, he or she must have intelligence and be able to meet people in an agreeable way, and must have consideration for the lady of the house, who will not be favourably impressed if she has to clean up after being paid a visit. Women, however, should be cautioned against gossiping or discussing anything concerning neighbours; they are calling on business, and by adhering to that idea will produce the best impression. In Brockton special care is taken over the investigation of complaints, which are attended to at once, and form the first item in the day's work. Sympathetically regarded complaints form one of the best avenues to new business. They afford an opportunity of entering the consumer's house at his own desire and establishing friendly relations.

Great importance is attached to the sale of really serviceable articles. It is no use "pushing" an inferior fixture. "The lamp selected should be the best that can be offered for the money. It

pays to install good gas appliances; shoddy appliances mean trouble for the gas company, whatever their origin." Mrs. Howard has formed the impression that folders, photographs, etc., are less useful in the sale of lighting fixtures than the exhibition of the actual article. The best impression is made by the lamp installed in the room itself and in operation. the view that consumers are unwilling to pay fair value for a serviceable article is held to be incorrect. According to experience in Brockton, the best price for a fixture is 15—25 dollars (approx. £3). The mistake is often made, however, of putting a price of 30 dollars upon a fixture that ought to be sold for 15. An illustration is given of the semi-indirect fitting developed in Brockton, which carried a handsome ornamental glass bowl, frosted and embossed with flowers, decorated in three colours, and having either rod or chain suspension. It is desirable to change the design about every third year.

Experience in Brockton suggests that it is as easy to sell to tenants as to property owners. It is a curious anomaly that while tenants naturally take their rugs and furniture with them when they move, they are apt to leave their fixtures behind, possibly because the gas company has not suggested to them the idea of regarding the fitting as their permanent property. Where gas companies have shown no disposition to accommodate owners of such fixtures by disconnecting them and installing again in the new home, there has been little inducement to tenants to own them. If gas companies can remove a meter from one house to another why not also fixtures? Consumers are usually willing to pay a reasonable figure for such service.

The terms for the sale of such fixtures are 1 dollar cash and 1½ dollars per month, rendered with the gas bill, until the 15 dollars are paid. This includes free maintenance and replacement of mantles for one year. Mrs. Howard believes that consumers should be encouraged to spend on illumination. Why not show them that they will get more out of good light per dollar invested than out of anything else they can buy?

Finally the method pursued in Brockton is summarised as follows:—

(1) Combination of maintenance work with the sale of appliances.

(2) Terms and commissions which make the plan self-sustaining and compensation adequate.

(3) Securing business that keeps going 365 days in the year, in times of both war and peace.

(4) Demonstrations of the fitness and efficiency of women for such work.

(5) Showing that consumers will pay a fair price for a good fixture.

(6) Locating combined maintenance-selling service representatives in definite districts, each responsible for about 2,000 consumers.

(7) The salary insures regular maintenance services and the commission is an incentive to intelligent and enthusiastic selling effort.

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## CO-OPERATION BETWEEN GAS AND ELECTRICITY.

In moving the adoption of the accounts for the year 1917 at the annual meeting of the Gas Light and Coke Co. on February 8th, Mr. John Miles (Governor) mentioned that the question of the future supply of electricity in this country was being made the subject of inquiry by several Government Committees. This, he said, was a matter which was being watched with close interest by the directors, and they were of the opinion that there was no reason why there should not be close co-operation between the gas and electrical industries. They believed that such co-operation would be very much to the benefit of the public.

This point was also the subject of reference at a meeting of the Consultative Committee of the National Gas Council on February 19th, when it was mentioned that the Chairman of the Executive Committee (Mr. D. Milne Watson) had been invited to give evidence before the Board of Trade Electric Power Supply Committee. Mr. Milne Watson urged co-operation between electric and gas interests, and pointed out that the long experience of gas companies would enable them to deal very effectually with the work of carbonising coal, recovering its by-products and supplying heat units to electrical undertakings for steam-raising.

# STREET LIGHTING IN ISLINGTON.*

IN a recent number of the *Electrician* an abstract is given of a report presented to the Metropolitan Borough of Islington by Mr.(now Lieut.-Commander R.N.V.R.) Haydn T. Harrison in September, 1917. The report furnishes an interesting example of the problems facing many public authorities at the present time.

The report deals with the suggestion that the diminution in lighting could be more economically carried out by substituting " half-watt "incandescent lamps or the existing arc lamps (now masked). Where possible this has been done ; in April, 1917, 120 out of 284 open-type arc lamps and 92 out of 240 flame arcs were so converted. But the system of high-tension alternating current adopted nearly 25 years ago prevents such alterations being carried out in entirety ; on the other hand, the substitution of half-watt lamps, according to a method involving an alteration of the system of distribution, would not be advantageous so far as after-war conditions are concerned.

The approximate candle-power of the electric street lamps in use before the war were 500, 700, and 2,500 respectively. The former were spaced 180 ft. apart, the latter, on the average, 260 ft.

| Arc Lamps. | | | | Half-watt Lamps. | | | |
|---|---|---|---|---|---|---|---|
| No. | Watts. | Illum. (Ft.-c.) | Costs. | No. | Watts. | Illum. (Ft.-c.) | Costs. |
| 90 | 550 | 0·02 | £1,595 5 0 | | | | |
| 157 | 700 | 0·03 | 3,598 11 5 | 740 | 150 | 0·08 | £6,505 16 8 |
| 123 | 800 | 0·03 | 3,111 7 9 | | | | |
| 290 | 700 | 0·044 | 7,415 10 10 | 580 | 300 | 0·06 | 8,047 10 0 |
| | Total annual cost | | £15,720 15 0 | | Total .. .. | | £14,553 6 8 |
| | | | Saving per annum, £1,167 8s. 4d. | | | | |

Spaced as the lamps are at present, after the war demands would not be satisfied by altering the present flame arc lamps, and no gain would result from changing the 500 c.p. and 700 c.p. lamps to any type of lamp other than flame arc lamps.

The estimates provided by the engineer for operating half-watt and arc lamps show that a material saving could be made by installing lamps of lower candle-power during the war ; for example, £17 per lamp per annum could be saved by replacing the 2,500 c.p. lamps by 250 c.p. lamps. On the other hand, if it were necessary to revert to 2,500 c.p. lamps after the war, using half-watt lamps, a loss of £21 per lamp would result, plus the capital cost of changing over. Preferably, any scheme adopted for present economies in annual expenditure should form part of a scheme for improving conditions after the war.

This is complied with by the following scheme : If lamps are placed at 130 ft. and 90 ft. apart a minimum illumination of 0·1 ft.-candle is obtained when lamps of 800 c.p. and 300 c.p. are used. The use of 250 c.p. and 500 c.p. lamps would enable the illumination to be increased three times. These positions are equivalent to the addition of lamps midway between existing lamps, and would involve alteration of connections to existing mains, but not new mains, the new posts and fittings being erected on the present lines of mains, and connected to the same when they have been changed to the short parallel system. The annual costs of all these lamps would be less than that estimated for after-war prices of arc lamps :—

The reduction in spacing of the lamps would render it possible to economise by switching out alternate lamps at midnight, an operation which would produce a total saving of approximately £2,500 per annum.

The preliminary cost of carrying out the change would be approximately £3,000.

The additional posts, lanterns, etc., required to complete the scheme (about 660) would cost from £12 to £15 each, amounting in all to about £9,000.

* Abstract of a report presented to the Metropolitan Borough of Islington, September, 1917 ; *Electrician*, February 15th, 1918.

## A URANIUM CALCIDE ARC LAMP.

Reference is made in the *Electrical World* to a U.S.A. Patent No. 1,235,996, taken out by W. R. Mott.

The highest candlepower in commercial arc lights has hitherto been obtained by the use of calcium fluoride as the main constituent, which produces a yellow flame. In certain cases, however, a pure white light is a desideratum, this being particularly true of photographic and photo-engraving work. For general street lighting also a white light is to be preferred. In order to obtain an intense light of snowy whiteness the use of uranium, as an ingredient together with calcium fluoride, is suggested.

Uranium in the electric arc probably gives more lines in the spectrum than any other known element, and the arc is exceptionally rich in the blue and violet rays, while it also contains a considerable number of ultraviolet rays. It is also stated that uranium has the unique distinction of giving 50 per cent. more photographic power when used in the arc than rare-earth fluorides or titanium oxide. Moreover, when mixed with calcium fluoride in making up an arc lamp electrode it fully blends with the yellow rays of the latter to produce an intense snow-white light of extraordinary photographic power.

## THE ILLUMINATION OF WATER-COLUMNS.

An interesting special problem in lighting, referred to in *Electricity*, is the treatment of columns of water, such as those in gauges for boilers. In many cases the level of the water in the gauge is not clearly evident with ordinary methods of illumination, the actual position of the water being masked by reflection from the glass.

It is stated that the difficulty may be overcome by placing a strip of white enamelled metal, about 4 in. by 20 in. in dimensions, 3 in. to one side of the glass and about 6 in. away from it. An adjacent lamp can then be made to throw a well-defined shadow of the glass tube on this strip. Owing to the high refraction in the part of the tube filled by water the shadow will be black above the water level and very much lighter below; moreover, should the glass break, the lamp, being comparatively distant, would not be affected.

## AN INDUSTRIAL LIGHTING CODE FOR OHIO (U.S.A.).

According to the *Electrical World*, much interest is being taken in the proposed code of lighting for workshops and factories in the State of Ohio (U.S.A.), more than 300 representatives of industrial plants and factory inspectors being present at a discussion held in Cleveland on this subject on January 16th.

The proposed rules are based largely on recommendations made by the Illuminating Engineering Society (U.S.A.), a feature being the classification of industrial operations under the various grades of intensity of illumination required. This is stated to be the first attempt to present a detailed schedule of this nature. There seems to have been general agreement with the values proposed, several factory managers pointing out that they were well within the limits adopted in their own shops. The discussion turned chiefly on the legal interpretation of the code, and questions of liability under special conditions.

Exhibits were on view to illustrate the fundamental principles of the code, as regards avoidance of glare, diffusion, intensity, etc., and motion pictures were employed to show the relation between accidents and faulty illumination.

## THE COMBINATION OF GENERAL AND LOCAL LIGHTING.

In a recent paper before the American Illuminating Engineering Society, Messrs. F. C. Caldwell and W. M. Holmes discussed the desirable proportions in which general and local lighting should be combined. From a series of tests made in a small room with white ceiling and simple, dark-coloured walls and surroundings, the authors drew the conclusion that with light ceiling and dark walls, and 2—6 foot-candles illumination on the work, 40 per cent. of local and 60 per cent. of general lighting is preferred, both by men and women.

# TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all bona-fide information relating thereto.]

## B.T.H. FLOODLIGHT PROJECTORS.

THE accompanying illustration shows one of the new B.T.H. Floodlight Projectors, an account of which is given in a recent leaflet issued by the British Thomson Houston Co., Ltd. With such an apparatus a flood of light can be concentrated over a large area, and it has special applications in lighting docks, shipyards, &c., and in facilitating night work on the repair of buildings, bridges, and ships. Floodlighting has also been largely employed by railways in goods yards and for quarries and salvage work, a particularly interesting instance of its utility being as an adjunct to the operations of fire brigades. Even under war conditions there are many opportunities for the use of such units and, after the war, when lighting restrictions are removed, their applications will naturally be largely increased.

As shown in the illustration, the unit consists of a mirror, in appropriate casing, at the focus of which is placed an appropriate incandescent electric lamp which may be of 300, 500 or 1,000 watt size. With the lamp correctly adjusted to focus a divergence of 5 to 15 degrees on either side of centre is obtained, the maximum candlepower being 50 to 100 times that of the lamp.

B.T.H. Floodlight Projector on Tripod.

Some fuller particulars of the uses of such floodlighting units, and further details of their construction, are given in the list, copies of which can be obtained from the British Thomson-Houston Co., Ltd., Mazda House, 77, Upper Thames Street, London, E.C.

## SCIENTIFIC GAS BURNER PRODUCTION.

AT the recent meeting of the Institution of Gas Engineers, Dr. Charles Carpenter referred to the importance of scientific gas burner production. Burners, he said, must be tested systematically before being sent out to the trade. There has been some further correspondence on this point in the *Gas Journal*, Mr. F. J. Gould, Chairman of the Bland Light Syndicate, detailing the tests to which burners issued by this firm are habitually subjected, with a view to securing uniformity of action and reliability in practice.

Dr. Carpenter, however, in a subsequent letter, indicates that what is really needed is a modification in type, as well as careful testing previous to issue. "If we are to maintain our gas lighting," he says, "I contend that we must have a burner which needs only placing in position, and then works right away, as does the electric bulb, without requiring at each point skilled adjustment of ejector and air passages. We shall then obtain the equal of the electric lamp in simplicity of use. If, in addition, we can, by the tap on the fitting, vary the amount of light we obtain within very considerable limits we shall have something which the electric bulb does not give without considerable complication."

Simplification of burners in this direction would undoubtedly be a great advantage to the gas industry, and, as is well known, the South Metropolitan Gas Company have made considerable progress in this respect. Dr. Carpenter mentions also that he has had burners of this kind working for several years in the district of the Gas Light and Coke Company with complete success.

## INVERLITE FITTINGS IN A TOOL SHOP.

WE have received from the Wardle Engineering Co., Ltd. (Manchester), a picture postcard illustrating the use of the "Inverlite" Fittings, with a vitreous enamelled top reflector, an opalba bowl, and 150-watt gas-filled lamp, in a large tool shop. The illumination secured in these circumstances amounted to 6-foot candles, and it is added that glare was eliminated and better diffusion of light secured.

The advantages of this semi-indirect system of lighting was shown by the fact that it is now possible to carry out the testing of fuses by artificial light with the same accuracy and dispatch as by daylight; whereas before this change in lighting was made, the whole of the work done by the night-staff had nearly always to be re-examined during the following day.

This is referred to by the Wardle Engineering Co., Ltd., to whom we are indebted for the above particulars, as a striking illustration of the benefit of good lighting in munition factories.

## "THE WELDING TEST."

A LITTLE booklet, entitled "The Welding Test," just issued by Barimar, Ltd., a London firm which, we are informed, has built up an almost entirely new business of metal fusion for the repair or re-creation of fractured parts of machinery, deals with a highly technical subject in simple language. It is stated that one firm has brought back into commission more than 20,000 British derelict machines now engaged on National Service. Many of the delicate processes by which complete metal fusion is brought about were practically German preserves in pre-war days. The booklet will be read with interest, and copies will be sent post free on application to Barimar, Ltd., 10, Poland Street, Oxford Street, W. 1.

## GAS TRACTION WITH COMPRESSED GAS.

We observe that permission has been granted for the Gas Traction Committee of the Petroleum Executive to carry our experiments on a commercial scale with compressed gas in metal cylinders up to 1,800lb., with a view to post-war development. The Committee is also providing a gas traction section for exhibition at the forthcoming British Scientific Products Exhibition.

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## AUTOMOBILE HEADLIGHTS OF EXCESSIVE BRILLIANCY.

AT the meeting of the London "Safety First" Committee on July 18 a report from the Street Lighting Sub-Committee dealing with the above question was adopted.

Attention is drawn in the Report to accidents attributed to the excessive brilliancy of headlights on ambulances, military cars, &c., driven at a comparatively high speed. With a view to avoiding accidents, precautions are necessary as regards both the power and the mode of directing the light in such headlights, and the following recommendations are made:

(*a*) No portion of the beam of light shall fall outside a plane parallel to and 42 inches above the roadway measured at a distance of 100 feet from the vehicle.

(*b*) There shall be sufficient light to enable a person or object of substantial size to be distinguished at a distance of 100 feet ahead of the vehicle.

(This probably requires a beam of 500-1,000 c.p. if dark objects are to be distinguished at the distance specified. In these circumstances the illumination, at a distance of 100 feet, would be 0.05—0.1 foot-candles. In obtaining this value the design of the lens and reflector is more important than the candle-power of the lamp, but a suitably designed lamp consuming 10-15 watts of electricity, or an acetylene lamp consuming ¾-1 cubic feet of gas per hour, would probably suffice.)

(*c*) The illumination produced on the roadway at a distance of 100 feet shall not sensibly diminish for a distance of 5 feet on either side of the centre of the beam.

(*d*) There shall be sufficient side-illumination to reveal any person, vehicle or substantial object, on either side of the vehicle or 10 feet ahead of it.

The Lighting Sub-Committee suggest that this Report should be brought to the notice of the Council of the Red Cross Society and of the other authorities dealing with the matter.

## REVIEWS OF BOOKS.

*"Dynamo and Motor Attendants and Their Machines." By Frank Broadbent. (S. Rentell and Co., Ltd., London; ninth edition, 3s. 6d. net; pp. 212; 107 illustrations.)*

ELECTRICAL engineers and engineers in charge will welcome the ninth edition of this handy little book by Mr. Broadbent, which contains a great deal of sound and practical advice.

Following an introductory chapter containing general information the author proceeds to explain the fundamental principles of alternating and direct current machinery, and gives some hints on the choice and erection of dynamos and motors. A specially useful section of the book is that given to common sources of breakdown in motors and starting gear. The explanations are assisted by the liberal use of clear diagrams. Altogether this is a useful book for attendants on machinery and engineers to have by them.

*Report of the General Meeting of the Vereins deutscher Eisenhüttenleute, held in Dusseldorf on April* 14, 1918.

Sir Robert Hadfield has sent us a copy of the translation, prepared by him, of the above Report. It is well that we should have such accounts of technical proceedings in Germany, and anyone reading this translation will form an excellent idea of the strength of the German iron industry and the energetic steps that are being taken for its development. Of special interest is the attention bestowed on research. After enumerating a large number of investigations that are in progress, the Report deals with the co-operation of the iron and steel producers in conjunction with the new Kaiser Wilhelm Association, which in April of last year founded the Institute of Iron Research. The whole of the German iron industry, it is stated, has given its support to this Institute, and the leading works of Austria-Hungary have entered into agreement to join. These facts should not be lost sight of by the British iron industry, and Sir Robert Hadfield has done good service by drawing attention to them.

*Journal of the Society of Glass Technology (Vol. II., No.* 6, *June,* 1918).

The most recent issue of the *Journal of the Society of Glass Technology* maintains the high standard of its predecessors, and contains a considerable amount of useful information. Apart from the more technical matter the Presidential Address of Mr. W. F. J. Wood, entitled "A Brief Review of the Present Position of the British Glass Industry," and the discussion on "The Glass Industry After the War," make interesting reading. That the industry has difficulties to overcome all must recognise, but it is a good omen to find that they are being discussed and that manufacturers are feeling their way towards concerted action. We observe that a resolution was adopted in favour of the formation of a Federation of employers and employees to eventually take the place of the present temporary Industrial Reconstruction Committee for the Glass Industry.

At the conclusion of the volume will be found the usual summary of articles in the technical Press relating to glass manufacture.

*Twelfth Annual Report of the British Science Guild (July,* 1918).

The twelfth annual report of the Executive Committee of the British Science Guild, just issued, shows that the Guild is fully maintaining its activity. Memoranda on various educational topics, and reports on the Metric System and the British Dye Industry are presented, and an account is given of the proceedings at the annual meeting on June 19, at which addresses were delivered by Lord Sydenham, Sir Algernon Firth, and Sir Henry Newbolt.

Special interest attaches to the announcement of the forthcoming British Scientific Products Exhibition, which has been arranged to take place at King's College, London, during August and September.

# 7

*10/6 Yearly.* THE JOURNAL OF SCIENTIFIC ILLUMINATION. *1/- a Copy.*

OFFICIAL ORGAN OF THE

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# EDITORIAL.

## The British Scientific Products Exhibition.

The British Scientific Products Exhibition, which is being held at King's College, London, from August 12—September 7, marks an interesting departure and is a creditable result of the enterprise of the British Science Guild. The objects of the exhibition were admirably expressed by Professor R. A. Gregory in his address delivered at the meeting of the Circle of Scientific Technical and Trade Journalists, held on August 12, and again in the address of Lord Sydenham when officially opening the exhibition on the following Wednesday. The exhibition should serve to stimulate public confidence in the capacity of British scientific men, in co-operation with industrial enterprise, to secure and maintain a leading place among progressive nations; its object is, broadly speaking, the full development of the country's mental and material resources.

In the account of the exhibition given on pp. 171-176 in this number we refer to many of the chief features of interest. While it is necessary to admit frankly deficiencies revealed by the war, as a preliminary to remedying them, it is also encouraging to take stock of progress and record instances in which gratifying advances have been made. Naturally the exhibition can only select instances of such advances; it cannot attempt to portray the whole field. Many highly interesting developments connected with naval and military operations, aircraft, etc., cannot be

revealed at present, but may be dealt with in the future; some industries, on account of their size and complexity or the special nature of their products, do not readily lend themselves to exhibition within a limited space. There remain, however, many striking instances of progress exemplified in the exhibition, and further details are given in the series of contributions by experts in various fields, which form the forepart of the descriptive catalogue, and in the series of lectures delivered.

We are glad to record that ILLUMINATING ENGINEERING received due recognition, the Illuminating Engineering Society being represented on a special committee dealing with this matter, and a lecture on "Illuminating Engineering in Peace and War," delivered by the writer on September 2. A number of exhibits deal with lamps, lighting appliances and various optical developments, and references thereto are made in several of the introductory contributions in the catalogue. Permission was also granted by the Ministry of Munitions for the exhibiting of several special photometers, devised for the purpose of measuring the illuminating power of fluctuating sources of light of high intensity, and applied by a committee of the society engaged in special researches on flares, parachute lights, etc. ILLUMINATING ENGINEERING is one of the best examples one could select of applied science, and artificial lighting, equally important alike in peace and war, is surely to be reckoned among the "key-industries" on which the promoters of the exhibition rightly lay such stress.

In view of the technical nature of the exhibition the attendance has been good, and it has received attention in the Press. We regard as its most important function the stimulus given to public interest in the applications of science to industry, and the educational influence exerted. Encouraging as are the instances of progress it presents we must guard against the hasty assumption that in three or four years of strenuous endeavour the deficiencies of half a century can be made good. Science itself is international. Any important advance in our acquaintance with natural phenomena, in whatever country it is made, quickly becomes common property and is embodied in the general store of scientific knowledge. Where countries differ is in their readiness, as a result of the technical education they have received, to apply their scientific knowledge for practical ends. In order to foster the appreciation of what applied science can do, and ultimately to bring about a national consciousness of the benefits of scientific and industrial research and technical education, propaganda must be continuous and not spasmodic. We are therefore glad to learn that there is a prospect of the exhibition becoming a permanent annual event.

It only remains to congratulate the promoters of the exhibition on the success that has attended their efforts. We should like, without undue discrimination among the many enthusiastic workers who have contributed to this success, to mention particularly the efforts of the Chairman of the Executive Committee, Professor R. A. Gregory, and that of the Organising Secretary, Mr. F. S. Spiers. The facilities afforded, both to the technical and the lay Press, have been well devised, and the exhibition has received from them a very valuable measure of co-operation in making its aims and objects known.

## The Report of the Committee of the Privy Council for Scientific and Industrial Research (1917-1918).*

The Report of the Committee of the Privy Council for Scientific and Industrial Research for the year 1917-18, makes interesting reading, and affords encouraging evidence of the expansion of the work, considering the difficulties imposed by the war. It appears at an opportune moment, when the British Scientific Products Exhibition is illustrating the practical results of research.

The Report falls into two sections dealing respectively with Industrial Research Associations and Researches initiated by other bodies aided by grants from the Department. It is gratifying to note that there are now thirty such associations at work, and the Committee have taken a very judicious step in advocating the formation of research associations by the Standing Industrial Councils now being created in accordance with the recommendations of the Whitley Report. The wider the common interests that can be established between masters and men on such councils, the better their chance of success. We can hardly imagine a field more likely to encourage concerted effort than the initiation of industrial research.

A considerable variety of investigations are now being undertaken by special Boards and Committees. Among these may be mentioned the inquiries on Industrial Fatigue, Food Preservation, the Production of Tin in Cornwall, and the Tests on Home Grown Timber with a view to Afforestation. The proposals of the Fuel Research Board for an experimental station at East Greenwich are now being carried into effect. The enquiry into industrial fatigue is a specially promising field for investigation, which, as we have frequently pointed out, is closely allied with problems involved in the effect of industrial lighting on health and output. No doubt these aspects will be considered by the Committee.

A considerable amount of work is also being done by the various bodies associated with respective industries, special reference being made to that of the British Scientific Instrument Association and the Standing Committee on Glass and Optical Instruments. A brief reference is also made to the steps being taken for the encouragement of research in Canada, Australia, New Zealand, and India, and we hope that there will be constant co-operation and interchange of views with the bodies thus developing in the chief Colonies and Dominions.

Meantime the training of scientific workers needs special study. We have at present far too few workers in the field of pure research, but, as the diversity of processes shown at the British Scientific Products Exhibition clearly illustrates, the numbers required for the direct application of science to industry are larger still. We should like to emphasise, therefore, the comments in the Report referring to the vital importance of a proper recognition of the value of scientific training on the part of manufacturers. In order to induce young people to prepare themselves by scientific training to enter the industrial field as researchers, adequate remuneration and reasonable prospects of advancement must be forthcoming. Only thus can science and industry work hand in hand for the fullest development of the nation's resources.

* Cd. 9,144. Price 4d. net. Published by His Majesty's Stationery Office, Imperial House, Kingsway, London, W.C. 2.

### The Standardisation of Lamp-Voltages.

We have frequently referred to the inconveniences attending the multiplicity of lamp-voltages in this country, which is troublesome alike to makers of electric incandescent lamps and to those who have to carry large stocks. In particular, it interferes with the continuity of manufacture and its standardisation. In the United States co-operation between lamp makers, supply companies and the public facilitates standardisation and has had very beneficial results. By concentrating on a convenient range of voltages better and cheaper lamps can be produced.

We are therefore very glad to observe the announcement of the Tungsten Lamp Association, which proposes an important simplification in this respect. In principle, formal endorsement is given to the standards advocated by the B.E.A.M.A. and the British Engineering Standards Association, namely, 100, 110, and 115 (for low voltage), and 200, 220, and 230 (for high voltage), although at present it is not proposed to initiate an immediate alteration to these limits. As an intermediate step the following standard voltage range is proposed:

Under 100 volts: 25, 50, and 55.
Low voltage: 100, 105, 110, 115, 120, and 125.
High voltage: 200, 210, 220, 230, 240, and 250.

Lamps of these voltages will be supplied at standard prices, but an extra charge will be made for all lamps of intermediate, higher, or lower voltage. In Continental practice the number of voltages in regular demand is limited to one or two in both high and low voltage range, while in the United States and Canada there is a strong movement towards reducing the number of standard voltages to not more than three, such as the present policy of the T.L.A. aims to ultimately secure.

The present step is thus merely an introductory one, but it is a hopeful indication that still greater simplification will be possible in the future. At the present moment, when the demand on the efforts of lamp manufacturers throughout the country is exceptionally severe, any measure which tends to simplify their task will be of great benefit. Progress towards a still more limited range of voltages naturally depends to a great extent on the future conditions of electrical supply, but it may be confidently expected that methods of reconstruction will be such as to diminish considerably the variety of voltages at present in use. Meantime the policy of the lamp-manufacturers will have a useful influence. We trust that the same considerations will be brought to the notice of large consumers of lamps for special purposes, *e.g.*, those required for the Army and Navy, the aggregate of which is very considerable. In equipping the ships constantly being brought into service it would be advantageous if agreement could be reached on a few standard voltages and types of lamps which should be adopted throughout the Navy and the mercantile marine.

The action of the T.L.A. is a hopeful indication of fuller co-operation in these matters, which we trust will meet with due encouragement.

LEON GASTER.

# THE BRITISH SCIENTIFIC PRODUCTS EXHIBITION.

**(HELD IN LONDON, AUGUST 12th-SEPTEMBER 7th, 1918.)**

THE British Scientific Products Exhibition now taking place at King's College, London, which is under the patronage of H.M. the King, and includes amongst its Vice-Presidents the Prime Minister and many of the leading Members of the Government, is an important landmark in the industrial development of this country. The Exhibition is intended to illustrate progress in the application of science to British industry since the outbreak of war, and affords a good opportunity of stimulating public interest in scientific research. It has attracted a considerable number of visitors, and has been the subject of very full reference both in the technical and daily Press.

### MEETING OF THE CIRCLE OF SCIENTIFIC, TECHNICAL AND TRADE JOURNALISTS.

On the first day, August 12th, a meeting of the Circle of Scientific, Technical and Trade Journalists was held at the Exhibition by the invitation of the Executive Committee, a most inspiring address being delivered by Professor R. A. Gregory. Mr. L. Gaster (chairman of the Circle), who presided, briefly referred to the objects of the Exhibition and the encouraging evidence of progress it afforded. He hoped that the present year would mark the beginning of a new era in technical education and scientific research. In this field the British Science Guild, who were responsible for the Exhibition, had done valuable pioneering work. It should be the task of journalists to widen the circle of those interested in such matters until the whole nation had become imbued with the scientific spirit and with a proper appreciation of its value to industry.

Professor R. A. Gregory pointed out that industrial progress seemed to involve the efforts of three distinct types of specialists: the creative investigator who discovered new properties and relationships; the inventor who applied such knowledge for practical purposes; and the artisan concerned in the construction of devices or their technical use. During the past four years the gap between science and industry had been bridged to a great extent. Industrial co-operation was becoming more general, and there was less of the distrust which formerly existed between men of science and manufacturers. The aim of the Exhibition was to stimulate public confidence in the capacity of British scientific workers, helped by industrial enterprise; to secure and maintain a leading place among progressive nations; its objects the full development of our mental and material resources.

Professor Gregory added that many of the greatest inventions had originated in Great Britain, and under the stress of war a great deal of lost ground had been recovered. Among the most interesting developments had been the manufacture of many valuable chemical drugs, such as salicylic acid, aspirin, phenacetin, etc.; of photographic chemicals, synthetic dyes and associated products; and many other substances previously imported from abroad. Equally striking had been the developments in optical and chemical glassware when enemy supplies were cut off owing to the war. The pure potash needed in making certain glasses was being prepared by a new electrolytic process; the magneto industry had become firmly established; hard porcelain fittings for electrical and laboratory use had been developed; many rare metals were being worked, including the tungsten required for electric lamp filaments and for many special steels; aluminium alloys superior to anything produced before the war were now available.

The Exhibition thus afforded an object lesson to the public of the capacity of scientific workers and the adaptability of manufacturers. But the future industrial success of the nation depended upon the fuller recognition of the value of higher scientific education and research, and a great deal of ground had to be made good before this country could be said to stand in the same position as some other progressive nations.

A vote of thanks to Professor Gregory, moved by Mr. P. A. Gilbert Wood and seconded by Mr. W. A. Standring, terminated the proceedings.

### LORD SYDENHAM'S OPENING ADDRESS.

The Exhibition was officially opened on the Wednesday following by Lord Sydenham, whose address also strongly emphasised the claims of technical education. While the United States has 40,000 full-time day students in the colleges of agriculture and mechanic arts, and Germany 16,000 to 17,000 in the technical high schools alone, there were not 5,000 students in the whole of the technical colleges and applied science departments of universities in this country. Five individual States in America each devoted a larger sum to its university institutions each year than is granted to the universities and colleges of England and Wales. An adequate supply of technical workers was of grave importance for the future, for on this both the safety and industrial prosperity of the country ultimately depended. The Education Act would materially assist the rank and file of industry, but sufficient had not yet been done to train the captains and pioneers of applied science. The State that neglected the training of these leaders could not expect to maintain a high place among the progressive Powers of the world.

### LECTURES, DEMONSTRATIONS, AND DESCRIPTIVE CATALOGUE.

A good feature of the Exhibition is the series of demonstrations and periodical lectures by specialists which, it is understood, will be issued in published form. The descriptive catalogue, besides particulars of exhibits, contains a series of contributions by experts in various fields, summarising progress since the outbreak of war. Thus Professor Gregory deals with "The Recovery of the Key Industries," Dr. W. E. S. Turner with "The British Glass Industry," Mr. W. R. Cooper with "Electrical Apparatus and Appliances." A note on Industrial Research Associations is contributed by the Department of Scientific and Industrial Research; a section on "Illumination" is contributed by Mr. L. Gaster.

The lectures and demonstrations, which cover a great variety of topics, have been most helpful in explaining the nature of the exhibits, and supplementing them by information on the industries concerned.

### "ILLUMINATING ENGINEERING IN PEACE AND WAR."

A lecture on the above subject was delivered by Mr. L. Gaster on September 2nd. The lecturer remarked that light had been a subject of veneration in quite early times, and that many of the earliest inventions and discoveries in the field of artificial lighting were made in this country. Sir Humphrey Davy developed the principle of the electric arc, the late Sir Joseph Swan was one of the inventors of the electric incandescent lamp, Murdoch was named "the father of gas lighting." Since the outbreak of war manufacturers had risen to the occasion in meeting the requirements of many essentials in the lighting industry, for which we were previously dependent on imported supplies, and the knowledge acquired before the war of the proper utilisation of light had been of equal importance. In regard to illuminating engineering—the application of light for practical ends—this country might claim to have taken the lead in advance of the rest of Europe during the past ten years.

Light, Mr. Gaster pointed out, was

equally important both in peace and war. Modern warfare, on land, at sea, and in the air involved the continual use of artificial light, in the form of searchlights, luminous signalling devices, flares and star shells, etc.; even the art of "camouflage" necessitated a knowledge of the laws of light and the peculiarities of the human eye. Behind the lines, in factories and munition works, light played an equally important part. Artificial lighting, in short, should be regarded as one of the most important "key-industries," and it was of vital importance to encourage the development of essential lighting apparatus in this country. Illuminating engineering was one of the best examples one could take of applied science, and the artificial lighting industry was essentially a scientific one.

Mr. Gaster then proceeded to give several instances of how conclusions formed before the war had been found to apply at the present time. The principle that the proper lighting of shop-windows should involve no exhibition of unscreened brilliant lamps, had been early applied to shop-lighting in war time. Similarly the uniformity of illumination and absence of excessive contrasts in light and darkness in the streets had been found desirable, though in part for different reasons, in war time as well as in the days of peace. Such conditions could only be attained after the war by some form of central supervision, with a view to establishing uniform practice in street-lighting throughout London. The measurement of illumination had been an important feature in planning lighting installations, and in researches on illumination before the war. Subsequently it had been applied by two committees of the Illuminating Engineering Society to certain problems, including the study of star-shells, parachute-flares, etc. The lecturer showed and explained two novel photometers for the latter purpose, which had been exhibited at the Exhibition by permission of the Ministry of Munitions.

In conclusion, Mr. Gaster pointed out that illuminating engineers would play a great part in reconstruction problems after the war, suggesting, as an instance, the establishment of a new branch of illumination, the provision of illumination and luminous devices for the needs of aerial traffic. Science itself was international, and any new discovery of natural laws and phenomena, wherever made, quickly became embodied in the general store of knowledge. Where nations differed was in their readiness, as a result of technical education, to apply science to the practical problems of life. It was to be hoped that one result of the Exhibition would be a great stimulation of public appreciation of the importance of technical education and scientific research to the industries of the country.

### THE EXHIBITS.

Within the space available it is naturally impossible to give more than a very general idea of the exhibits, a great diversity of products and industries being represented.

*Drugs, Chemicals, Gas Traction, etc.*

The sections devoted to dyes and colours, synthetic drugs and chemicals, and the exhibit of the Gas Traction Committee also aroused interest. The London General Omnibus Co., Ltd., had on view a standard motor-'bus with high-pressure gas stored in metal cylinders at 1,000lb. per square inch, a reduction to about 1lb. per square inch being automatically produced at a valve, and the gas then passing into a flexible reservoir on the canopy. Flugel & Co., Ltd., showed high-pressure fittings and equipment, including gas carburetter, combined reducing valve and expansion chamber effecting reduction from 120 atmospheres to one atmosphere; and a specimen steel cylinder holding approximately half a cubic foot at atmospheric pressure.

*Minerals and Metallurgy.*

In the Metallurgical Section there are also many interesting things to be seen. Hadfields, Ltd., exhibit a number of special steels and specimens

illustrating the effect of projectiles on armour plate. The Research Department have arranged a large temperature chart, a prominent exhibit on entering the entrance hall, ranging from absolute zero to the temperature of the sun and showing the principal temperatures for metallurgical operations. Among other metallic products we may note the " Igranic " rust-proof metal, the preparations of magnesium, bronze and other special powders, and the complex processes involved in the reduction from the crude ore of tungsten—an important constituent both of special steel and of the filaments of electric incandescent lamps. Electric welding outfits and gas and electric furnaces are also represented; an impressive exhibit being a large carbon electrode of a type now being made for the first time in this country. The magneto industry is in evidence as another good example of post-war development, and the importance of this key-industry in relation both to aircraft and automobiles needs not be laboured.

*Miscellaneous Exhibits: Instruments, etc.*

There are many other miscellaneous exhibits on which we should like to dwell, but we can only briefly mention the displays of cord and other materials made from paper; the exhibits of the sands obtainable in this country which have proved so useful in the making of refractory substances and various kinds of glass; the sections devoted to paper and textiles, illustrations and typography, and the exhibit of the food production and conservation.

Scientific apparatus and instruments are well represented. The National Physical Laboratory fill a room with their exhibit of electric standards, projection apparatus for the accurate determination of the pitch and testing of gauges, the ship-models employed in the Froude experimental tank, etc. In the Optical section the Meteorological Office show some interesting apparatus for determining air-velocities and air-temperatures up to heights of 30 kilometres. These small balloons used to convey apparatus to these heights, are fitted with a small candle and lantern so as to render them visible by night.

Sir Robert Hadfield also exhibits a complete model of the United Engineering Societies' building in New York.

*Optical Appliances and Illumination.*

We will conclude our account by a reference to some of the exhibits of interest in relation to illumination bearing on illumination and optics.

Lamps and lighting accessories are represented by relatively few exhibits, no doubt because manufacturers have been mainly occupied in meeting requirements for standard articles, and have not yet been free to commercialise many new types. Among lamps exhibited we may note, however, the gas-light fittings, specially adapted for use in munitions and chemical works, shown by Benjamin Electric, Ltd.; the Blanchard incandescent oil lamps which includes a special portable outfit for war work, *e.g.*, the lighting of hospital tents, etc.; and the display of incandescent oil lamps by the Kitson Empire Lighting Co., Ltd. The Bland Light Syndicate show a variety of their gas lamps and burners. The Edison Swan Electric Co., Ltd., has a miscellaneous exhibit including tungsten minerals and products, glass bulbs used both for electric lamps and the gas-filled lamp in various stages of manufacture. The Pointolite lamp, as a highly interesting example of invention since the outbreak of war, is naturally included in this exhibit. Duram, Ltd., exhibit their drawn tungsten wire, together with samples of tungsten and molybdenum ore, illustrating the various stages of development. We understand that the entire process, from the reduction of the ore to the drawing of the wire, is now undertaken in this country, and that the output to foreign markets has now reached an average of 600,000-700,000 metres of tungsten wire per week. Be-

sides its primary use for filaments of electric lamps, we are informed that the finest drawn wire finds various special applications, *e.g.*, for the cross wires in certain telescopes and optical apparatus.

The incandescent mantle industry is represented by Messrs. Curtis's and Harvey, the Ramie Co., Ltd., and the London Thorium Co., who show various chemicals derived from the by-products, such as cerium chloride, oxalate and fluoride, etc. Various types of mercury vapour lamps and ultra-violet sterilisers, etc., are shown by the Westinghouse Cooper Hewitt Co., Ltd.

The section on aircraft includes several interesting lighting appliances, including the landing headlight, using a bunched electric filament and short focus mirror, of Messrs. Joseph Lucas, Ltd., who also exhibit their Infantry Daylight Signalling and Tank Starting and Lighting outfits.

We also observe a compact form of "artificial daylight" apparatus, designed by Mr. Lionel Pearce and exhibited by Messrs. Coney's, Ltd. (Birmingham), utilising a 20 watt incandescent lamp and a special colour screen. The construction of the lantern precludes the interference of outside light, and the arrangement appears convenient and economical in consumption.

Among miscellaneous appliances involving the use of light, Mr. Fournier d'Albe's apparatus for teaching the blind to read through the recognition of a musical note, in place of the printed letter, has attracted much interest. It will be recalled that this device—the "optophone"—depends on the variation in light reflected from different letters, as detected by a selenium cell, which converts the reflected light into sound by means of a specially-tuned telephone. Every letter of the alphabet has thus its characteristic sound, and it is claimed that no raised type or special printing is needed, and that any language can thus be read by ear. Other illustrations of the use of selenium are furnished by the model of an automatic lighthouse, automatically extinguished by daylight and switched on again in the dark, and the "photophone" device for the transmission of invisible Morse signals.

Glassware forms an important feature of the exhibit. The Department of Glass Technology at Sheffield University had a stand comprising glass tubing and rod, bulbs for electric lamps of non-lead glass, specimens of chemical glassware and some beautiful examples of selenium glass, all produced in the laboratories of the Department. The British Chemical War Manufacturers' Association, Ltd., show a great variety of chemical and laboratory glassware and apparatus for bacteriological research, as now being manufactured in this country. Messrs. Chance Bros. and Co., Ltd., exhibit specimens of optical glass for scientific purposes, including a 28in. Crown disc for an astronomical refractor. It is of special interest to note in this exhibit the heat-resisting glass globes and cylinders for high and low-pressure gas lighting, incandescent oil lighting, and for the enclosure of certain types of arc lamps. Miners' lamp glasses, acid-resisting glassware and special laboratory and engineering glassware form the subject of the exhibit of Messrs. John Moncrieff, Ltd.; and the Silica Syndicate, Ltd., has a remarkable display of transparent quartz glass, which owing to its heat-resisting power, its very low co-efficient of expansion, and its resisting power to all known acids, except hydrofluoric acid, has many similar uses. It is stated that from such glass complicated apparatus is constantly being constructed which would be quite impracticable with ordinary glass, and the size of the articles is being continually increased. Among other special glasses may be noted those resisting the passage of ultra-violet light exhibited by Sir William Crookes, who also exhibits specimen salts of the rare metal scandium. Samples of "anti-glare" glass prepared in accordance

with Sir William's formulæ are also shown by Melson Wingate, Ltd.

The Illuminating Engineering Society has exhibited, by permission of the Ministry of Munitions, two special forms of photometers designed for the comparison of fluctuating lights of high candle-power, such as star-shells and the parachute lights, in the study of which two committees of the Society have been engaged. The varying nature of such lights makes it difficult to obtain data with an ordinary type of photometer requiring manipulation in order to obtain balance; before such an adjustment can be made a change in the light commonly occurs. Accordingly the special instruments enable the balancing point to be observed merely by inspection, without manipulation. In one case this is effected by placing a small lamp at one end of a tube with a whitened interior, in the front of which a whitened metal plate with stencilled letters cut out is inserted. A series of letters of progressively increasing brightness, each corresponding to a certain definite illumination, is thus obtained. In another case the "lumeter" principle is adopted, the observer looking through a series of slots of graded brightness at a test-screen on which the illumination to be measured is received.

A very interesting feature in the optical section is the use made of luminescent paints and powders used for gunsights and the figures on dials of nautical and aeronautical apparatus which require to be seen in the dark. Excellent examples of the use of such materials are to be seen in the aircraft section, and in the beautiful nautical compasses and other apparatus in the Admiralty exhibit. As is well known, the substance commonly employed is luminescent zinc sulphide with a small admixture of radium salts as the excitant, and Mr. F. Harrison Glew, who has long been associated with the preparation of such substances, is showing some of their chief applications in a darkened room in the exhibition. The exhibits comprise a variety of specimens glowing in the dark, including the small tubes which are turned out in very large quantities for gunsights, etc. There were a number of other appliances which bear witness to the ingenuity of Mr. Glew and the important applications which these substances are finding in connection with the war.

The Cold Chemical Co. have likewise an exhibit of phosphorescent zinc sulphide, obtained from Germany before the war, but now made in this country in greatly improved quality. Other materials shown include phosphorescent calcium sulphide, large quantities of which are used on the field of warfare, and calcium tungstate, synthetic willemite and other materials, largely used for X-ray work, a special feature here being the absence of "afterlight."

Optical and photographic apparatus was well illustrated at the Exhibition, special features being the 150 cm. searchlight reflector exhibited by Messrs. C. A. Parsons and Co., Ltd., and the large aperture lenses used by aircraft in reconnaissance photography.

Enough has been said to show that the Exhibition furnished many interesting instances of apparatus and materials constructed or developed for the first time in this country since the outbreak of war and of the very creditable efforts which manufacturers have made to cope with the difficult tasks which the present emergency has imposed on them.

The British Science Guild are to be congratulated on the enterprise shown in organising this exhibition, and in undertaking the very considerable amount of work involved. We are very glad to hear that it is proposed to make the British Scientific Products Exhibition an annual feature, and we trust that it will continue to record instances of the successful application of scientific methods and knowledge to the industries of this country.

## THE LIGHTING RATION IN PRACTICE.

THE general recommendations on Economy in Lighting, issued by the Illuminating Engineering Society with the concurrence of the Board of Trade, were recently presented in this journal.* Starting from the hints given in these recommendations, it is now proposed to indicate roughly how the lighting rations under the Household Fuel and Lighting Order may be expected to apply to two typical houses, having respectively six and twelve rooms.

In each case both gas and electric lighting are considered. The distribution of the consumption of a household naturally varies considerably according to the habits and occupation of the inmates, the presence of children and other factors. The examples given are only intended as a rough indication of the requirements of typical families and, by a slight readjustment of the amounts, can be made to apply to most ordinary cases.

Bearing in mind that 1 ton of coal can be converted into 15,000 cubic feet of gas or 800 units of electricity, it is clear that the consumption for lighting is in general but a very small proportion of the total fuel ration. Consumers, therefore, should aim first at judicious economies in heating and cooking, and the saving thus made should enable them to obtain adequate illumination without undue difficulty.

### (1) A SMALL HOUSE WITH SIX ROOMS AND SIX OCCUPANTS.

We will assume that this house contains six occupants, namely, the parents, three children, and one servant, and the following rooms: Sitting (or Drawing) Room, Dining Room, Kitchen, and three Bedrooms; other small areas, such as bathroom, hall, landing, stairs, etc., have to be lighted but do not count as "rooms" in the Order. The house will therefore be entitled to either 11,250 cubic feet of gas or 180 units of electricity for lighting, as well as the fuel ration.

*Gas Lighting.*—Taking first the sitting room (or drawing room), the chief essential is to provide sufficient light for reading, writing, sewing, etc. This can conveniently be done by a central burner over the table, consuming approximately 3½ cubic feet of gas per hour and equipped with a suitable shade. If located about four feet above the table the illumination necessary for most kinds of work (3-4 foot-candles) will be exceeded, and the area lighted should be sufficient to enable several people to work simultaneously. The room being relatively small, say, between 150 and 200 square feet in area, it should also be possible thus to provide a moderate general illumination and to avoid objectionable contrasts of light and darkness. There may, however, be several smaller burners about the room for occasional use. The question next arises how often the room will be in use. If occupied habitually the lights would be needed for about 1,000 hours in the course of the year. But in a house of this kind the dining room would probably be used for reading and writing, etc., as well as for meals, as this would involve only one fire being used instead of two. The sitting room (or drawing room) might be set apart for special occasions, and the consumption during the year for lighting might thus be put at about 2,000 cubic feet.

Taking next the dining room, which is the one chiefly in use, if this is of the same size as the sitting room and lighted in the same way, the central light, taking 3½ cubic feet per hour, will be practically all that is really needed, and on the 1,000-hour basis will consume 3,500 cubic feet in the course of the year. The kitchen will probably be somewhat smaller, but there may be also a scullery and more early morning light may be needed; we might, therefore, put the consumption at 4,000 cubic feet during the year.

In the three bedrooms well-shaded burners consuming about 2¼ cubic feet

* ILLUM. ENGINEER, May, 1918, pp. 131-133.

per hour, placed over the dressing tables, will answer requirements. As there are several children in the house it is as well to assume that light will be needed in the bedroom, on the average, for ¾ hour per day. The consumption in three bedrooms would thus amount to about 2¼ x ¾ x 365, or say, in round figures, 2,000 cubic feet.

There remains the allowance of gas for lighting bathroom, stairs, passages, etc. The bathroom, like the bedroom, will only be used for short intervals. It would not be desirable to leave the stairs unlighted, but the passages hardly require continuous illumination. By judicious economy and the use of burners of the smallest consumption (bijou type if possible), equipped with bye-passes, it should not be difficult to keep the consumption for these miscellaneous items within, say, 1,000 cubic feet.

The total consumption is thus distributed as follows:

CONSUMPTION PER YEAR, CUBIC FEET OF GAS.

| | |
|---|---|
| Sitting Room (or Drawing Room. only in use occasionally) ... ... ... ... | 2,000 |
| Dining Room (the room chiefly occupied) ... ... ... | 3,500 |
| Kitchen ... ... ... | 4,000 |
| Three Bedrooms ... ... | 2,000 |
| Bathroom, stairs, landing, etc. | 1,000 |
| Total ... | 12,500 |

(*b*) *Electric Lighting.*—Treating the electric lighting on the same basis it appears that a satisfactory illumination over the table in the sitting room might be secured from a 40-watt tungsten lamp, well shaded, and situated 4 feet above the table. During the year such a lamp would consume 40,000 watt-hours, *i.e.*, 40 units if used for 1,000 hours. A couple of additional 20-watt lamps, only rarely used, would consume say another 10 units in the course of the year. The sitting room would use 50 units on this basis. But assuming again that this room is only occupied occasionally and that the family make use of the dining room for reading, writing, sewing, etc., as well as for meals, we might take only two-thirds of the above consumption for the year, *i.e.*, about 35 units.

Assuming similar conditions of lighting in the dining room, but allowing the full amount corresponding to 1,000 hours use, we arrive at 50 units, while in the kitchen we will again allow a somewhat larger amount, say 60 units.

In the bedrooms there may be 30-watt lamps over the dressing tables, and if the rooms require light, on an average, for ¾ hour each day, the consumption in the three rooms in the course of the year would be: 30 x ¾ x 3 x 365 watt-hours, or, say, in round figures 25 units.

We are thus left with 30 units for the lighting of bathroom, stairs, landings, etc; this should be sufficient if only lamps of the smallest available consumption are used on stairs, landings, etc., and only switched on just when they are required. The consumption in the house is thus distributed as follows:

CONSUMPTION PER ANNUM, UNITS OF ELECTRICITY.

| | |
|---|---|
| Sitting Room (or Drawing Room only used occasionally) ... | 35 |
| Dining Room (the room chiefly in use) ... ... ... ... | 50 |
| Kitchen ... ... ... ... | 60 |
| Three Bedrooms ... ... ... | 25 |
| Bathroom, stairs, landing, etc. | 30 |
| Total ... | 200 |

Houses of much smaller dimensions than the above need not be considered as their lighting ration is ample and in many cases their requirements would be so small as to bring them outside the Order.

The lighting ration, both for gas and electric lighting, has been thus slightly exceeded. The consumer must, therefore, either practice a little additional economy or convert a small amount of fuel, say, ¼ ton into gas or electricity for lighting.

(2) A LARGER HOUSE WITH TWELVE ROOMS AND NINE OCCUPANTS.

In this case the house is assumed to be occupied by a family in good circumstances comprising the father and mother, two adults and two young children, and three servants, namely, nurse, cook, and housemaid. The house contains a Dining Room, Drawing Room, Library or Reading Room, Kitchen, Day Nursery, Night Nursery, and Six Bedrooms, one of which is a spare bedroom. The following will not count as "rooms" under the Order, but will require light: Bathroom, Scullery, Pantry, Lavatories, Hall, Landings, and Stairs.

Rooms will be of larger proportions in this house. Let us assume that the drawing room has a capacity exceeding 4,000 cubic feet (thus counting as "two rooms" as regards the fuel ration), and has a floor area of approximately 350 square feet, that the dining room occupies 300 square feet, and the library and kitchen each 250 square feet. The lighting allowance for the 12 rooms is 18,750 cubic feet of gas or 300 units of electricity per annum.

*Gas Lighting.*—Taking first the drawing room, we will assume that this is frequently occupied by a number of people, and that it is desired to illuminate the whole with a moderate intensity of 1.25 foot-candles. Referring to the table in the recommendations already quoted* we may assume that, with light walls, this illumination requires about 15 cubic feet of gas per 1,000 square feet, and that the consumption will be of the order of 4½-5 cubic feet of gas per hour. The consumption during 1,000 hours, in the course of the year, will thus be about 5,000 cubic feet of gas.

The dining room need not be completely lighted. There might be a burner consuming say about 3½ cubic feet per hour over the table, and lights consuming together another 9 cubic feet per hour round the room. Probably the full light from all these burners would only be used very occasionally. In general only the central light would be used for meals, say 450 hours during the year, and one of the small burners for clearing away, etc., also for about 300 hours. The total consumption for the year might therefore be within 2,500 cubic feet.

The library or reading room being intended for serious work, should be well lighted. There will presumably be a well-shaded burner over the table and sufficient illumination from adjacent lights to enable shelves, etc., to be seen. If we assume an average illumination of one foot-candle over the 2,500 square feet occupied by the room, the average gas consumption need not exceed 3½ cubic feet per hour for 1,000 hours, say 3,500 cubic feet for the year. This should be within the mark as the reading room will certainly not always be used at the same time as the drawing room. About 5,000 cubic feet might be allocated to the kitchen, scullery, and pantry.

The bedrooms might again be provided with burners over the dressing tables consuming about 2¼ cubic feet per hour, and if we assume that in this house they are used for an average of ¾ hour per day, the consumption per room might amount to 600 cubic feet during the year, or a total of 3,500 cubic feet for the set of six bedrooms, one of which is a spare room and not always in use. To this is to be added the consumption of the night nursery, where the nurse sleeps with the two young children, and where we should allow somewhat more gas—say another 1,000 cubic feet for the entire year. As regards the day nursery it may be assumed that the children retire early to bed, but the room be used afterwards by the nurse for sewing, etc., at times when she is not in the night nursery. Bearing this in mind, 2,000 cubic feet seems a fair allowance for the year.

There remain the miscellaneous areas, bathroom, stairs, hall, landings, etc., which might be computed to require rather more than twice the consumption allowed for the smaller house, *i.e.*, 2,500 cubic feet.

* ILLUMINATING ENGINEER, May, 1918, p. 133.

The total consumption for this house therefore works out as follows:

| Consumption per Year, Cubic Feet of Gas. | |
|---|---|
| Drawing Room ... ... | 5,000 |
| Dining Room (only used for meals) ... ... ... | 2,500 |
| Library or Reading Room ... | 3,500 |
| Kitchen, Scullery, and Pantry | 5,000 |
| Day Nursery ... ... ... | 2,000 |
| Night ,, ... ... ... | 1,000 |
| Six Bedrooms ... ... ... | 3,500 |
| Bathroom, Hall, Landings, Stairs, etc. ... ... ... | 2,500 |
| Total ... | 25,000 |

This total exceeds by 6,250 cubic feet the lighting allowance of 18,750 cubic feet. The consumer must either practise further economies or make good the excess by converting a part of his fuel ration to gas for lighting. As there are twelve rooms in the house, one of which (the drawing room) counts as two, and the number of occupants exceeds six in a house of not more than 12 rooms, the fuel allowance is 13 tons of coal (under Scale B which applies to London). By converting half a ton into gas for lighting, an additional 7,500 cubic feet of gas is obtained, and this would more than cover the excess; or the consumer might convert a quarter of a ton, thus obtaining 3,750 cubic feet, and reduce his consumption by 2,500 cubic feet. He would probably be well advised to convert half a ton, thus obtaining quite comfortable lighting conditions, and retaining 12½ tons (or its equivalent in gas) for heating and cooking.

*Electric Lighting.* — Taking the rooms in the same order as before we will first deal with the drawing room, the area of which is about 350 square feet. Assuming again that we produce an average illumination of 1.25 foot-candles, we shall not be far out in allowing 0.3-0.35 watts per square foot. This means a consumption of say 100 watts, and, on the 1,000 hours' basis, 100 units in the course of the year.

In the dining room a cluster of lamps in a shade over the table, consuming say 90 watts and used for about an hour and a half per day, would account for say 50 units during the year, and an additional 15 units might be allowed for the small amount of light required in clearing away meals, etc.; 65 units in all.

In the library, lighted on about the same basis as the drawing room, we might allow 80 watts, *i.e.*, 80 units per annum. In the kitchen, scullery, and pantry a somewhat larger amount, say 100 units.

The day nursery and night nursery, treated as before, might be allotted 40 units and 20 units respectively. In the bedrooms, if we assume that a 30-watt lamp is used in each case for an average of ¾ hour daily, we arrive at a total consumption during the year of about 60 units. For the bathroom, stairs, landings, etc., we will again allow twice the amount assumed in the smaller house, namely, 60 units.

The total consumption is therefore made up as follows:

| Consumption per Year, Units of Electricity. | |
|---|---|
| Drawing Room ... ... ... | 100 |
| Dining Room ... ... ... | 65 |
| Library ... ... ... ... | 80 |
| Kitchen, Scullery, and Pantry | 100 |
| Day Nursery ... ... ... | 40 |
| Night ,, ... ... ... | 20 |
| Six Bedrooms ... ... ... | 60 |
| Bathroom, Stairs, Landings, etc. | 60 |
| Total ... | 525 |

The lighting ration of 300 units is thus exceeded by 225 units. This could again nearly be met by the conversion of a quarter of ton of coal, giving an additional 200 units, and it would probably be worth while for the consumer to make the small further ecomony needed to keep within this additional amount, rather than to convert half a ton of coal (giving an additional 400 units more than he really needs). The sacrifice of ¼ ton should not be seriously missed.

In houses of larger dimensions than the above the conditions are broadly similar, but as the allowance of gas and electricity for lighting increases more slowly with the number of rooms, it becomes somewhat more difficult to keep within the lighting ration if such rooms are habitually illuminated. On the other hand, the fuel ration increases by 1 ton per annum per room so that a larger amount can be spared for conversion into gas or electricity for lighting.

The above figures are based on the assumption that lamps and burners are used, on the average, for 1,000 hours in the course of the year. If, however, the occupants use their rooms somewhat freely at night it would be as well to allow for 1,300 hours use, the amounts allotted being increased pro rata. The data also assume average quality of gas and normal conditions of electric lighting (*e.g.*, the use of ordinary tungsten filament incandescent lamps). Some latitude must be allowed as regards the consumption of units. Thus gas burners have been taken to consume $3\frac{1}{2}$ and $2\frac{1}{4}$ cubic feet of gas per hour. But the consumer who desires to economise could, by judicious selection and adjustment of burners, obtain approximately 2 or 3 cubic feet per hour; or, in cases where a strong light is needed, could use burners consuming 4 cubic feet per hour. Similarly electric 40 watt lamps have been frequently assumed in the above calculations, as the type most usually employed for single lights illuminating a table of fair size; to obtain an illumination equivalent to that obtained from a gas burner consuming 3 cubic feet per hour it would be necessary to use a 60 watt lamp in most cases.

Naturally much depends on the habits of the occupants of a house, and the extent to which they can secure the co-operation of servants and others of the household, but the examples given will serve as a rough indication of the course to be pursued.

## ADVICE ON THE HOUSEHOLD FUEL AND LIGHTING ORDER.

We have frequently pointed out the valuable assistance that gas and electricity concerns can render in explaining the above Order, and advising consumers how best to comply with its requirements. It is interesting to note that advisers on gas and coke have been appointed, on the nomination of the National Gas Council, to assist the Fuel Overseers in the respective districts. Following a recent meeting of the Divisional Officers a standing Conference was formed to deal with any problems that may arise, the Chairman being Mr. F. W. Goodenough, who is also chairman of the sub-committee of the National Gas Council appointed to watch the working of the Order.

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A very useful little booklet has also been prepared by the British Commercial Gas Association, chiefly for the use of officers concerned with the Order. It contains a series of tables showing the quantities of gas that can be requisitioned according to the various quantities of coal required for each size of house or tenement up to 20 rooms and in the districts under Schedule B of the Order. In each case the supply of coal and the amount of gas that can be used for lighting and for fuel respectively are set out in parallel columns.

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A little pamphlet entitled "Lighting Hints" has also been issued by the British Thomson-Houston Co., Ltd., containing a short account of the Order and of the allowances for fuel and lighting. Instructions how to read an ordinary electric dial meter are also included in the leaflet, and there are some useful hints on the management of light, special importance being attached to the choice of efficient lamps and lighting accessories, and to cleaning at periodical intervals in order to eliminate waste of light by absorption.

## THE TRANSMISSION OF LIGHT THROUGH WATER.

In a communication to the *General Electric Review* (*U.S.A.*), Mr. S. L. E. Rose gives the results of some experiments on the transmission of light through water. The amount of light absorbed in passage through the air varies according to the amount of mist, suspended dust, etc., but with a clear atmosphere is relatively small. The loss of light in passage through water—even water that is substantially free from impurities—is very much larger.

From his experiments on a sample of clear artesian well water Mr. Rose finds that the absorption by transmission can be represented by the following formula:

$$I \times I_0 \times T^f$$

where $I_0$ is the initial intensity, I the intensity after passing through $f$ feet of water, and T a constant, *i.e.*, the transmission through one foot of water.

The experiments were conducted by the aid of a tank enabling a depth of water up to five feet to be experimented upon. From these data T was found to have the value 0.725, *i.e.*, the light loses approximately 27.5 per cent. of its intensity for each foot traversed. The exponential form of the law shows that the diminution in light proceeds very rapidly. After passing through one foot of water 0.725 of the original light remains; in passing through the next foot all but 0.725 x 0.725, *i.e.*, 0.526 of the original light is gone; in the third foot the light is reduced to 0.725 x 0.526, viz., 0.381 of the original. When 10 feet have been passed through there is less than 1/20th of the initial light, while after passage through 100 feet it can be calculated that the light remaining is very minute—only 0.000,000,000,000,01 of the original!

One would like to see this figure checked by actual measurement on a relatively long length of water, but the experiment serves to demonstrate the difficulties of applying anything of the nature of a submarine searchlight in the under-water traffic of the future.

## THE ORIGIN OF FLUORESCENCE AND PHOSPHORESCENCE.

Readers will recall an interesting correspondence by Mr. A. L. Landau and Dr. S. E. Sheppard on the above subject which appeared in recent issues of this journal (June 1917, August 1917, and February 1918). We have now received a further communication from Mr. A. L. Landau, in which the complex chemical and physical phenomena underlying these effects are discussed in great detail and the behaviour of calcium tungstate and other substances under the influence of ultra-violet light and X-rays is analysed. In particular, Mr. Landau raises some interesting cases of materials being photo-luminescent while other closely allied substances for some reason are not so.

Owing to pressure upon our space we have been unable to print Mr. Landau's communication in this issue, but we hope to deal with it fully in our next.

## MESSRS. BENN BROS., LIMITED, TWENTY-SECOND ANNUAL MEETING.

At the twenty-second annual meeting of Messrs. Benn Bros., Ltd., on August 23, Mr. E. J. P. Benn, who presided, emphasised the variety of journals now under the control of the company, including the *Electrician*, the *Gas World*, *Aeronautics*, the *Cabinet Maker*, the *Export World*, and the *Fruit Grower*. In the course of his address Mr. Benn discussed the future of industry after the war, when great importance would be attached to the functions of the producer of essential commodities, and the relations between management and industry would be of great moment. The great movement initiated on the lines of the Whitley Report deserved the earnest attention of all citizens, and the vast industrial problems of the future opened out a vista of usefulness to the trade and technical Press.

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## THE INDUSTRIAL RECONSTRUCTION COUNCIL.

The Report of the Industrial Reconstruction Council for the six months ended June 30th, 1918, contains encouraging evidence of progress. We understand that the number of Standing Industrial Councils is increasing steadily, and it is obvious that there are many questions of common interest to workers and employers with which such bodies should deal. In the Report before us it is emphasised that the functions of the councils should not be limited only to "labour questions," but should include all the wider problems concerning industries as a whole.

The propaganda for the past six months has been conducted through many channels —important public meetings in London and the Provinces, lectures, distribution of literature, and concerted action with other bodies. Attention may also be drawn to the series of conferences on special topics connected with industrial reconstruction which have been arranged to take place in the Hall of the Institute of Journalists during the coming months. Addresses will be given by those prominently associated with the movement and followed by open discussion. No tickets are necessary for entrance, and full particulars can be obtained on application to the Secretary of the I.R.C., 2 and 4, Tudor Street, London, E.C.

The programme is as follows:—

| | Tuesday. | Speaker. | Chairman. |
|---|---|---|---|
| 1. Works Committees. | Sept. 10 | Mr. Robert Wilson (Ministry of Labour). | Mr. Ernest J. P. Benn. |
| 2. Trade Boards. | Sept. 24 | Mr. J. J. Mallon. | Dr. William Garnett. |
| 3. Interim Industrial Reconstruction Committees. | Oct. 8 | Mr. W. Henderson Pringle (Ministry of Reconstruction). | Sir Charles Allom. |
| 4. The Place of Conciliation and Arbitration in the Whitley Scheme. | Oct. 22 | Mr. E. H. C. Wethered. | Sir Alexander Roger. |
| 5. Women in Industry. | Nov. 5 | Miss Lilian Dawson (Fabian Soc. Women's Group). | Maj. Sydney W. Pascall. |
| 6. The Trade Union of the Future. | Nov. 19 | Mr. George A. Isaacs (Nat. Soc. Operative Printers and Assistants). | Sir Herbert Nield, K.C., M.P. |
| 7. Functions of Industrial Councils. | Dec. 3 | Mr. E. McGegan (Ministry of Labour). | Mr. Frank H. Elliott. |
| 8. Restriction of Output. | Dec. 17 | Mr. Wilfrid Hill. | Mr. Ernest J. P. Benn. |

## REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED

*"Elements of the Electromagnetic Theory of Light." By Prof. L. Silberstein. (Longmans, Green and Co., London, 1918. 46 pp. 3s. 6d. net.)*

THIS little book is largely taken from the author's Polish treatise on "Electricity and Magnetism," published by the help of the Misnowski Institution, and has been re-written at the instance of Messrs. Adam Hilger, Ltd.

The book contains a simple presentation of Maxwell's theory of light, always a difficult theory for those without facility in mathematics to follow, the treatment being mainly vectorial. Early chapters give an outline of the electromagnetic theory, its advantages over the elastic theory, and the application of Maxwell's equations to plane waves. The theory is afterwards applied to explain reflection and refraction and the properties of crystals. The book will doubtless be of interest to many students of optics and electricity.

*Circular of the Bureau of Standards, (Washington), No. 13, on "Standard Specifications for Incandescent Electric Lamps."*

This circular gives the general specifications under which lamps are purchased for the Government in the United States, including mechanical and physical characteristics of the lamps, the method of initial inspection, and tests to determine life and candle-power.

In the second portion of the circular the requirements, as regards efficiency and life, are specified for various types of lamps, including tungsten and carbon lamps from 110-125 volts and 220-250 volts respectively. In the case of vacuum tungsten lamps some readjustment of efficiency ratings have been made to meet the demands of the war. Gas-filled lamps have not hitherto been covered by these specifications, and manufacturing conditions are at present abnormal. The provision is therefore made that such lamps shall not be rejected if the life-test is not less than 1,000 hours, if lamps are allowed to fall to 75 per cent. of initial c.p.—though an average life of 1,000 hours with a drop to only 80 per cent. is expected. It is of interest to note that the specified consumption of gas-filled lamps, complying with these conditions and ranging from 75 to 1,000 watts, is put at 1.09 to 0.70 watts per mean spherical c.p.

Copies of this circular can be obtained on application to the Bureau of Standards.

*Preliminary Report of the Water-Power Committee of the Conjoint Board of Scientific Societies.*

This Committee was formed "to report on what is at present being done to ascertain the amount and distribution of water-power in the British Empire." Some highly interesting data have been collected; the water-power resources are shown to be enormous, but, except for certain localities, relatively little has yet been done to develop them.

It is stated that the potential water-power of the Empire amounts to 50-70 million h.p., much of which is capable of economic utilisation.

Various steps are suggested to survey and promote the development of these sources of water-power, in which the State should take a leading part.

## Obituary.

### DR. WILLIAM ETTLES.

We learn with regret of the death of Dr. W. Ettles, which occurred on July 19th. Dr. Ettles was well known to many members of the Illuminating Engineering Society, of which he was a member, frequently taking part in discussions on matters relating to vision. He also took a leading part in the work of the Optical Society, and various bodies concerned with Ophthalmology. Dr. Ettles was one of the first to recognise the importance of the physiological aspects of illumination, and will be greatly missed.

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# EDITORIAL.

### Economy of Fuel and the Selection of Lamps.

As the winter approaches the urgency of economy in fuel is becoming increasingly evident. The situation was explained to a representative gathering of Mayors of Metropolitan Boroughs and their technical assistants at the Mansion House on September 20th, when Sir Albert Stanley traced the course of events leading up to the present shortage. The need for economy should by now be generally appreciated. It may be necessary to keep these facts before the public notice, but at this stage it is even more important to explain how economies can best be effected.

So far as lighting is concerned, this journal has endeavoured to make some simple general recommendations, and in our last number we showed, by typical examples, how the lighting of two houses of small and moderate size might be adapted to the requirements of the Household Fuel and Lighting Order. Among the points that have recently arisen is the use of supplementary means of lighting, oil lamps, candles, etc. We agree that it is desirable that consumers who have gas or electricity available should, so far as possible, avoid the use of these supplementary lighting accessories, which are badly needed by those who have no gas or

electric light. Light for light, a candle is an inefficient appliance, although it has the advantage of portability and is useful as a "night-light," where only a very feeble illumination is needed. While it is right that waste in light should be avoided and a saving in the gas or electricity consumption is helpful, private consumers do not yet seem to realise how easily their lighting requirements can be met by the conversion of a small amount of their fuel allowance to gas or electricity.

In any case, the economy to be derived in domestic consumption is relatively small. As the figures quoted by Sir Albert Stanley showed, it will be necessary to look to industry for a more substantial saving. In regard to lighting, as we have pointed out before, economies which would have a prejudicial effect on safety, health, or quality or output of work are undesirable. In each case the drawbacks, as well as the advantages of apparent economies, should be carefully weighed before any drastic measures are adopted; mere diminution in the amount of light is not always judicious economy, and there are instances where a seemingly high illumination is justified by circumstances which are not obvious to the public. Some striking instances have recently been published of economies derived in munition works by various judicious steps, including the careful grading of illumination according to the nature of the work, the substitution of general overhead lighting for local lights, and the systematic extinction of all unnecessary lights. These steps, while conducive to economy, are essentially in harmony with the aims of illuminating engineering, and we can quite believe that in large establishments the saving in gas or electricity thus accomplished would be very substantial. A useful indication of the illumination necessary for different classes of work was afforded in the Appendix to the Recommendations on Economy in Lighting recently issued by the Illuminating Engineering Society, which appeared in our May issue (pp. 131-133).

Another very desirable form of saving is by the elimination of inefficient lamps and lighting appliances. In the United States the Fuel Administration have been in communication with the electric lamp industry regarding possible savings of this type. The leading companies have agreed upon the elimination of unnecessary types of carbon filament lamps and of carbon lamps for certain special applications. Furthermore, the installation and renewal of carbon filament lamps by central station supply companies is to be discontinued and the installation and renewal of "gem" (metallised carbon) filament lamps gradually abandoned. Attempts will also be made to recommend the substitution of gas-filled lamps for vacuum type lamps in sizes of 100 watts and over. The question of restricting the manufacture of 40, 50, and 60 watt tungsten lamps in favour of those of lower consumption (10, 15, and 25 watts) was also carefully considered, but judged to be impracticable. No doubt this step would present manufacturing difficulties, and might occasion a prejudicial indiscriminate lowering of the standard of illumination. In any case it could only be regarded as an emergency measure. But the elimination of carbon filament lamps is a progressive step of permanent benefit and furnishes an interesting example of co-operation between the Fuel Administration and the lamp industry.

**Public Lighting and the Preservation of Order in the Streets.**

A few months ago a request was made to the Authorities concerned with lighting for a further reduction in street-illumination to be permitted in the interests of fuel-saving. It was agreed that the diminution should be sanctioned, subject to revision at a later period should it be found that the reduced lighting led to increase in crime or danger to traffic, or impeded the police in the supervision of the streets.

We have reason to believe that the effect of further diminutions in illumination, in relation to street accidents, is being carefully watched, and no doubt the analysis of the returns of accidents, as soon as available, will determine what further action is to be taken. In view of the depletion of the police force it is highly desirable that their efforts should not be interfered with by the undue curtailment of lighting. It has been argued, with some reason, that the saving in coal, that can be secured through such reductions in public lighting, is not very great and any economies in this direction should be carefully weighed against the compensating drawbacks.

In particular, we should like to see a more general use of devices which, while complying with the requirements of the authorities, do not occasion undue waste of light. It is possible that considerations connected with air-raids may allow somewhat more latitude than was previously the case, and that therefore mere reduction in the amount of light, irrespective of economy, is less vital than heretofore.

Several instances might be mentioned where an improvement in illumination would appear to be justified. For example, additional light at the exits and entrances to tubes and the stopping places of trams, omnibuses, etc., would be of assistance in the interests of safety and convenience. This would facilitate the speedy entrance or departure of passengers and diminish the possibility of accidents through the sudden approach of other vehicles. Reference has also been made in the Press to the fact that gangs of pickpockets profit by the darkness in such localities and the crowded conditions of the pavement and roadway to pursue their nefarious trade. Improved illumination would prove one of the best deterrents to such practices.

We may also refer incidentally to a matter which has been much discussed in the Press recently, namely, the presence in certain streets of people of bad character who accost soldiers on leave and occasion moral irregularities. We think that there is a tendency in some quarters to exaggerate this evil, and that the dark conditions may sometimes lead to erroneous impressions. But there can be no question that darkness hampers the efforts of the authorities in discriminating between culpable and merely somewhat irresponsible behaviour. If the illumination in these crowded areas could be improved, preferably on lines which permitted the lighting to be extinguished in the event of a raid, not only would the prevention of such disorders be rendered easier, but the danger of false judgments lessened and the temptation to irregularities largely removed. It has often been said that each lighted lamp acts like the ideal policeman whose presence is necessary to preserve order, but compatible with legitimate freedom.

**Photometers for Measuring Mean Spherical Candle-power or Total Flux of Light.**

The growing recognition that the only satisfactory basis of rating illuminants is in terms of their total light-output in all directions has served to emphasise the need for rapid methods of determining either mean spherical candle-power or total flux in lumens. This matter is referred to in a recent contribution to the Société Internationale des Electriciens by Mons. Larnaude, which is referred to on p. 192 in the present issue. The author pointed out the great dissimilarity in the light distribution from various forms of electric incandescent lamps, and it is interesting to have this confirmation from France of a view which has been steadily gaining ground in this country. It may be recalled that some of the very earliest appliances for measuring total flux of light, the lumen-meters and meso-photometers devised by Professor A. Blondel, were originated in France many years ago.

This question of rating illuminants in mean sph. c.p. or lumens was dealt with in the discussion on "The lumen as a measure of illuminating power" before the Illuminating Engineering Society nearly two years ago, and we notice that a serviceable pamphlet, recently issued by the British Thomson-Houston Co., Ltd. (referred to on p. 201 in this issue), contains a general explanation of this lumen and its application in practice. We mention this to show how the conception of the lumen is being adopted by manufacturers and becoming familiar to the public. In the future rating in lumens will be greatly expedited if reliable apparatus enabling flux of light to be determined in a single measurement can be made available.

The forms of apparatus for the purpose fall broadly into two classes. We have firstly those employing combinations of mirrors, the integral contribution of which is a measure of the light in all directions. Recently a modification of this device has been suggested by Dr. J. Sahulka in which diffusing white plates are substituted for mirrors (see p. 195) and this seems to have some promising features.

The other class of appliances is typified by the integrating sphere or globe photometer, on which a considerable amount of experimental work has been done. Experience with such apparatus suggests that in the hands of competent experimenters results of very fair accuracy can be obtained. The chief drawback is that globes of this kind are somewhat expensive to construct, and it would be a great advantage if some simpler form, *e.g.*, a cubical box with whitened interior, would serve as a substitute. Experiments on this problem have been delayed through the war, though we understand that some tentative researches have been in progress. In the near future the matter will certainly require attention, and we hope that the earliest opportunity will be taken to grapple with the problem. If a sufficiently accurate and practical form of apparatus can be contrived there seems no reason why the determination of flux of light should not be carried out as expeditiously as the measurement of candle-power in one direction only, and familiarity with the process will doubtless soon overcome the incidental minor difficulties.

LEON GASTER.

# ROCKETS AND ILLUMINATING SHELLS AS USED IN THE PRESENT WAR.*

By A. BERGMAN.

## Rockets.

The value of rockets in war time was appreciated very early in history, but they were used practically only for signalling purposes up to very recent date. In the present war they are largely used to enable observers to discover any movements of the enemy. A given area is most effectively illuminated from directly above, although if the enemy is out in the open, for example, in the act of attacking, it is often of advantage to attempt to place the light behind him, as he will then present a silhouette target against the illuminated background. The light will then also be further away from our own trenches, leaving them in greater darkness. Another novel use for rockets and illuminating shells is as a "light barrage," behind which it is possible to execute movements without fear of discovery by the enemy. A "light barrage" is produced by causing a very large number of lights to burn continuously between the enemy's and our own trenches.

Rockets used are principally of two different kinds. The ordinary type finally bursts in a brilliant flash, illuminating a large area for a few seconds. The second type of rockets carries a parachute to which the star is attached. Through this arrangement it is possible to keep a brilliantly burning star suspended in the air for a comparatively long time, which is generally fixed to be about 30 to 35 seconds.

## Illuminating Shells.

The fundamental difference between illuminating shells and rockets is that while the rockets propel themselves through the air the illuminating shells are fired from a suitable weapon, including rifles, trench mortars, and field as well as naval guns.

It is a remarkable feat to fire illuminating shells from powerful naval guns. Part of the make-up of such a shell is of flimsy material such as the parachute, which in these shells are made of silk with its attachment of cords, etc. The shells are fired with a velocity of over 2,700 ft. (824 m.) per second, and the chamber pressure required, therefore, is nearly 20,000 lb. per sq. in. (1,400 kgm. per sq. cm.). A standard time fuse causes the shell to operate at any point up to several miles. The burst ignites and ejects the star with the parachute, which opens up and keeps the burning star suspended until it has consumed itself.

## General Description of Illuminating Shells.

The principal parts employed in the construction of illuminating shells are:

The TUBE, which forms the sides or body of the shell and is made of heavy, tightly rolled paper; or when the shell is intended for long-range shooting, of fibre or metal.

The BASE, made of wood or metal, in which generally a fuse and a bursting charge are located.

The TOP, which is simply a disc of wood, fibre, or other suitable material so attached that it can comparatively easily be forced out from the inside.

The STAR is a powerful illuminating compound made of various chemicals, such as barium, nitrate, potassium, perchlorate, powdered aluminium, magnesium, etc. These are carefully mixed and rammed hard into a container of suitable material.

This container has a top and side, usually cylindrical in form, and is filled to within about $\frac{1}{8}$ in. (0.32 cm.) of bottom with the illuminating composition. The remaining space is used for an ignition charge, such as finely ground black powder called "mealed powder."

The PARACHUTE is made of paper or silk and so packed together as to readily open when expelled.

* Abstract of a paper presented before the Illuminating Engineering Society (U.S.A.).

**Main Types of Illuminating Shells.**

By introducing a time fuse the star can be released and ignited on any desired point in the shell's trajectory.

Three different sizes and types of illuminating shells having the following characteristics seem desirable:—

| To be fired from | Max. range. |
|---|---|
| 1. Rifle (as rifle grenade) | 200 yards (183 m.) |
| 2. Trench Mortar | 1 mile (1.6 Km.) |
| 3. Field or Naval Gun | 3 to 4 miles (4.8 to 6.4 Km.) |

**A rifle illuminating shell** could be constructed very simply. A time fuse would hardly be necessary, but could easily be provided. The ignition of the fuse could be accomplished either through a channel in the rod or by using a plunger. Such a shell is not fired through the bore of a gun and does not receive such a severe shock as occurs with a longer range. This illuminant could be packed in a cartridge of sufficient strength to form the body of the projectile, to the head of which can be attached a pointed metal hood, enclosing a parachute.

Signal lights can also be substituted for the illuminant, so constructed that the colours could be made to burn in the desired rotation.

**A trench mortar shell** with a range of one mile requires a stronger construction than that necessary in the rifle variety. A range in excess of one mile (1.6 km.) can be obtained.

The satisfactory functioning of the parachute is a most important point. It should be as large as practicable, so as to prevent the star from descending too rapidly, but the greater the size the greater is the strain put on it when opening. Hence, in order to get the full benefit of a time fuse it is necessary, if the maximum range is made long, to use a small parachute.

For ranges of more than one mile (1.6 km.) it is advisable to so construct the illuminating shells that they can be fired from a standard field or naval piece such as the 3 in. (7.6 cm.) or larger guns. Radical changes in the design of such shells mentioned are necessary, but the fundamental principles are the same. It is also necessary, in this type of shell, to take into consideration centrifugal force and its action on the operation of the parachute. Provision for this must be made in the packing and by attaching sufficient cord or chain of suitable material adequately fitted with swivels between the illuminant and the parachute.

There is little advantage in producing an illuminant that will burn for an extended period, except possibly in coast defence work, in shells with a very long range, as even a moderate wind will, during a minute, carry the star a considerable distance. The more rapidly an illuminating compound is allowed to burn the more brilliant will be the light. It is thus best to limit the time element to a reasonable degree and to fire the illuminating shells so much more frequently. The parachute should be made of silk, which combines strength, light weight, ability to resist deterioration indefinitely when sealed in a shell, and the quality of not becoming so creased after long packing that the parachute might fail to operate correctly.

The parachute and the cords attached to it should be fireproofed to prevent the possibility of their being ignited by a spark.

**Candle-Power Developed.**

To determine the values of flares for illuminating purposes, the candle-power developed should be measured and the time of burning noted. The values obtained should be reduced, first, into candle-power seconds and then into candle-power seconds per cubic inch of composition. Only after obtaining these values is it possible to intelligently compare flares for the purpose of determining which develops the most candle-power.

The following table gives some actual data from photometric tests of eleven lights, the illuminating elements of whose composition were identical, differing only in the time in which they were allowed to consume themselves:—

TABLE I.—CANDLE-POWER AND TIME OF BURNING.

Diameter of illuminants 1.94 in. (4.92 cm.).

Burning surface 2.95 sq. in. (19 sq. cm.).

| | "A" | "B" | "C" | "D" | "E" | "F" | "G" |
|---|---|---|---|---|---|---|---|
| No. | Total length of light inches. | Total burning time seconds. | Average candle-power. | Burning time per inch seconds B / A. | Cubic inches of composition Ax2.95. | Total candle-power seconds BxC. | Candle-power seconds per cu.in. B / E. |
| 71 | 2.44 | 16 | 213,000 | 6.55 | 7.2 | 3,400,000 | 472,000 |
| 72 | 2 | 10 | 269,000 | 5 | 5.9 | 2,690,000 | 456,000 |
| 77 | 2.25 | 22.5 | 143,400 | 10 | 6.65 | 3,210,000 | 482,500 |
| 78 | 2.12 | 16 | 186,500 | 7.55 | 6.25 | 3,000,000 | 480,000 |
| 92 | 2.25 | 35 | 89,700 | 15.5 | 6.65 | 3,140,000 | 472,500 |
| 100 | 2 | 34 | 79,800 | 17 | 5.9 | 2,710,000 | 460,000 |
| 105 | 2.37 | 35 | 96,700 | 14.75 | 7 | 3,385,000 | 484,000 |
| 110 | 2.37 | 31 | 108,800 | 13.1 | 7 | 3,375,000 | 482,500 |
| 111 | 2.37 | 32 | 113,300 | 13.5 | 7 | 3,630,000 | 520,000 |
| 112 | 2.63 | 32 | 115,150 | 12.2 | 7.75 | 3,680,000 | 475,000 |
| 113 | 2.5 | 28 | 132,300 | 11.2 | 7.4 | 3,700,000 | 500,000 |

One had ignition charges resp. 0.62 (1.5 cm.) and 0.87 in. (2.21 cm.) long, which burned 4 and 5 sec. These values are not included in above data.

The candle-power seconds per cubic inch developed by these illuminants showed only slight variation, although the time of burning varied from 5 to 17 seconds per inch (2.54 cm.) and the candle-power from 269,000 to 79,800. The average candle-power seconds per cubic inch was about 480,000, which value can be used in fixing the value of this particular light. It is thus demonstrated by actual tests that a fixed volume of a fixed composition will develop a fixed number of candle-power seconds regardless of its speed or burning. (It is understood that no changes in the percentages of the various chemicals used in making up the composition be permitted in order to cause the fluctuation.) The time of burning, in the eleven sample illuminants used by us, was regulated only by treating the composition by various methods.

In the discussion of this paper it was stated by Mr. L. M. Waldo that parachute light could frequently be seen by aviators at a distance of 30-40 miles. Such flares burn for one, two, or even eight minutes. Absorption due to smoke is an important factor, and in some specially-designed flares this amounts to only 29 per cent. Such flares are usually tested under the protection of a smoke stack. Mr. C. E. Crittenden said the light in flares was derived from a flame and not a crater, and was, therefore, practically uniform except for the shadow cast by the base of the flare. Mr. N. Macbeth said that the effective area illuminated by the flares was about 600 yards diameter, and calculated that on the basis of a light of 150,000 candle-power being obtained for 30 seconds for an expenditure of 50 cents (approximately, 2s.), the cost of light is about 5-10 times that produced by gas and electric illuminants. Mr. Waldo also referred to the problem of the case of both aluminium and steel disappear very rapidly. Mr. L. C. Porter pointed out the advantage of illuminating a large area, rendering flares useful to aviators in selecting the landing-place —in contrast with searchlights, which only serve to illuminate a relatively confined area.

# THE ELECTRIC INCANDESCENT LAMP SITUATION IN FRANCE.

In a recent communication to the Bulletin of the Société Internationale des Electriciens, Mons. A. Larnaude gives some interesting facts regarding the electric incandescent lamp situation in France. Thanks largely to the extensive use of female labour, and improvements in mechanical processes, makers of electric lamps in that country are able to meet urgent present requirements although conditions are not yet normal. The annual production of French factories is about 15-20 millions of lamps per annum, and it is hoped that existing factories will be able to double this figure as scon as the glassworks are in a position to supply the necessary bulbs. There have been considerable developments in this last direction, and glassworks should be in a positior after the war to meet all requirements.

Carbon filaments are now only used in cases where strength of filament is the chief consideration. Practically all other incandescent lamps use tungsten filaments, the tungsten being derived chiefly from ores in South America, Burmah, and Australia. The tonnage necessary to meet the require ments of the lamp industry is relatively small. For example, a ton of the ore will provide for the manufacture of three million lamps. Experience shows that the earlier impression that it was necessary to form special tungsten-alloys in order to obtain the requisite ductility was erroneous; on the contrary the finest wire can best be drawn out from tungsten in a state of great purity. A 10-watt, 110-volt lamp utilises a filament only 1/50th of a millimetre in diameter, and such wire has to pass through more than 90 processes before the final product is reached.

Vacuum lamps with tungsten filaments are considered to work at 1.1-1.3 watts per mean hor. c.p., and to give a useful life of 1,000-1,200 hours. Gas-filled lamps giving from 400 to 3,000 candles, work at about 0.6 watts per c.p. Owing to the high temperature of incandescence attained the finest wires will not resist adequately in an atmosphere of nitrogen, and lamps giving less than 300-400 c.p. at 110 volts require argon, which M. Claude is now preparing on an industrial scale. The thermal conductivity of argon bears to that of nitrogen the relation 1 : 1.5—a difference which is sufficient to render practicable lamps giving 50-100 c.p., operating at less than one watt per candle, and having a normal useful life. Owing to the low dialectric cohesion of argon gas (only 38 as compared with 465) it is, however, necessary to employ a mixture of argon and nitrogen. In a 50 c.p. lamp about 400 mm. of wire is used.

In conclusion, M. Larnaude points out the great variation in distribution of candle-power met with in modern incandescent lamps, and emphasises the desirability of expressing values in lumens, a proposal which has met with support in Great Britain and the United States, but is still little used in France, although the lumen was officially introduced into the series of units specified in a law now before the Senate.

A matter of importance in this connection is the provision of appliances enabling the total flux of light of a source to be obtained by a single measurement similar to the mesophometers and lumen-meters described before the Society as far back as 1904.

There seems no reason to doubt that by the aid of such appliances values in lumens could be expeditiously obtained, especially as the process becomes more familiar and any inaccuracies incidental to the method are detected and removed.

## FLOOD LIGHTING CALCULATIONS.

From time to time particulars have been given in this journal of the application of flood lighting methods in the United States, both for spectacular purposes and as a protective measure in time of war. It is claimed that the illumination of areas round important bridges, munition works, arsenals, etc., is one of the most serviceable methods of ensuring the detection of any unauthorised person in the vicinity. Flood lighting has also many important applications for the purpose of enabling night work to take place, and there is no doubt that it will have useful fields of application in this country after the war.

It may be of interest, therefore, to deal with some of the calculations involved, which differ in some respects from those employed in ordinary illuminating engineering. Some useful data of this kind were given by Mr. H. W. Butler in a recent issue of the *General Electric Review (U.S.A.)*,* Naturally the application of such methods involves a knowledge of the nature of the unit employed, and the spread of the beam, but such information, it may be assumed, will be available for all standard types of projectors for such work.

The following is a summary of the degrees of illumination considered necessary for lighting the surfaces of buildings:

FLOOD LIGHTING ILLUMINATION INTENSITIES.

| | Character of surroundings. | | |
|---|---|---|---|
| | White way. | Residences. | Parks. |
| Dark Coloured Buildings ... | 20 ft.-c | 15 ft.-c. | 10 ft.-c |
| Medium " ... | 15 " | 10 " | 5 " |
| Light " ... | 10 " | 5 " | 3 " |

* *General Electric Review, U.S.A.*, Sept., 1918.

The factors that have to be considered will include the type of projector, spread of beam (8°-5 ), the area and distance of the illuminated object, the nature of its surface, and the nature of the surroundings. The last point must not be overlooked, as the effect of flood lighting depends essentially on contrast. Thus an object in a brightly-lighted thoroughfare (a " white way ") will require a considerably higher illumination than a similar object standing in a park, where the surroundings are relatively dark.

The data relating to projectors are conveniently presented in the form of graphical charts. Thus a family of straight lines, for various illuminations, will give the number of projectors of a given type necessary for a certain illuminated area, with a given dispersion of beam. Similarly for a given beam we can assemble in tabular form the diameter and area of illuminated surface, the illumination, and the corresponding distance.

As the flux of light contained within a given beam is a constant, the product of the illumination and the enclosed area should remain the same, irrespective of the distance, except for atmospheric absorption.

In order to illustrate the working out of an actual problem, Mr. Butler takes a case in which a building of 6,000 square feet area is to be illuminated from a distance of 130 feet, and assumes further that it is of a dark finish and situated in a " white way " area. A reference to the table given above shows that the illumination in this case should be 20ft.-candles. If an " L-12 " projector using a 1,000 watt lamp is employed, we can ascertain from the data relating to this unit the number of such projectors necessary to produce 3-20ft.-candles. Taking the 20 ft.-candle curve, and assuming 6,000 square feet, it is found that thirteen projectors are required. Other typical examples are worked out, the selection of the projector in each case depending upon the data available for each unit.

It is evident, therefore, that the information necessary for the rapid treatment of such problems is being assembled by manufacturers in the same complete way as for ordinary installations where the spacing, type of unit, etc., has been effectively standardised. With a knowledge of the flux and polar curve of any such projector it would, of course, be possible to work the problem out from first principles, but charts of the type referred to reduce the labour considerably.

## A MULTI-FILAMENT INCANDESCENT LAMP.

An interesting form of electric incandescent lamp, which is referred to in a recent issue of the *Electrical Review and Western Electrician*, appears to have been developed by Mr. T. B. Rider, a scientist, at Los Angeles, in California. The period of usefulness of an ordinary lamp is terminated when the filament gives way, and in most cases the rest of the lamp is still perfect when it is discarded. Mr. Rider accordingly proposes to mount in the same bulb twelve filaments, each of 25-candle-power. Four are lighted when the lamp is turned on, and the next four are automatically brought into circuit whenever a filament fails. In this way the life of the lamp is considerably prolonged. Thus, if the average life of a filament is assumed to be 1,000 hours, the lamp would still be giving 100 candle-power after 2,000 hours. Each filament burns independently of the others, and any one may burn out without the others being affected. When the first eight filaments are all burned out the remaining four filaments can be switched on, and these will continue to burn until the last one gives way. Thus, after the light has been reduced from 100 to 25 candle-power, one can still use the lamp in positions where only a relatively small candle-power is needed.

## ILLUMINATION AND DISORDERS ON AUSTRIAN RAILWAYS.

Recent articles in the Austrian technical papers show that the railway system in Austria is becoming much disorganised. One of the chief difficulties is the shortage of lubricants, through want of which rolling-stock shows a continual tendency to break down.

Another matter which has been giving considerable concern to the authorities is the increase in thefts. Among the measures recommended in a recent statement made in the Austrian Parliament is the better lighting of railway stations and their immediate environment. The diminution in lighting appears to have led to other troubles: for example, a recent collision is ascribed to the deficient lighting in the station where the accident occurred. Trouble has also been experienced through the uncertain action of signal lights, apparently due to shortage of good oil or lack of proper supervision owing to shortage of staff.

## AUTUMN ILLUMINATING ENGINEERING CONVENTION (U.S.A.).

The Illuminating Engineering Society in the United States is to hold its annual convention in New York on October 10th, 1918. Among the matters to be discussed are war-time lighting economies, the use of better lighting in speeding up war production and manufactures, the lighting of camps, the effect of lighting curtailment on crime, and automobile headlights.

## THE PHOTO-ELECTRIC SENSITIVITY OF BISMUTHITE AND OTHER SUBSTANCES.

A recent bulletin issued by the Bureau of Standards, Washington, describes some interesting experiments on the above subject by Dr. W. W. Coblentz. Some curious facts are reported, but it appears that none of the substances examined were as sensitive to the action of light as selenium.

## PROPOSALS FOR A NEW STANDARD OF LIGHT.

In a communication to the German Physical Society, Prof. E. Warburg recently made some proposals for a new form of standard of light. He recognises that, while its reproducibility is sufficient for practical purposes, the Hefner lamp has no rational basis; it involves many variable factors, such as the construction of the lamp, the constitution of the liquid fuel, height of flame, etc.

Accordingly, he proposes to take as a standard the brightness of a surface, maintained at a specified temperature, and forming the interior of a cavity (capable of observation through an aperture). The brightness of such a surface depends only on its temperature and not on the radiating substance.* The brightness being thus specified, in a direction normal to the surface, one can obtain any desired candle-power by specifying a convenient area. Thus, if it is desired to approach the brightness of an ordinary metal filament, the temperature of the cavity must be 2,300 degrees absolute. We should then obtain a convenient candle-power by using an area of about 1/25th of a square centimeter, but the value of the light source can be adjusted by altering the size of the aperture.

As a means of controlling the temperature, Professor Warburg recommends the use of the photo-electric potassium cell of Elster and Geitel, which is stated to be much more sensitive than any thermic method. The relation between intensity of light and deflection is of no consequence, the cell with its galvanometer serving only as an indicator, and the intensity of light falling on the cell being altered by means of a rotating sector-screen. It is suggested that in this control only light of a wave-length—0.656/$\mu$ (the red hydrogen line)—should be used. It is calculated, however, that in order to afford a reliable standard the light must be measurable to within 1 in 1,000, and the wave-length measured with somewhat greater accuracy. These requirements border on the unattainable, so that the operation of the standard would require considerable care.

*Presumably this refers to black body radiation, *i.e.*, radiation derived from the blackened interior of a hollow sphere, raised to incandescence.

## A NEW PHOTOMETER FOR MEASURING MEAN SPHERICAL CANDLE-POWER AND TOTAL FLUX OF LIGHT.*

In view of the tendency towards measurement in terms of lumens, or in mean spherical candle-power, much attention has recently been given to appliances of the type of the Ulbricht Globe, mirror integrating devices, lumen-meters, etc. An apparatus recently described by Dr. J. Sahulka* seems to present some advantages. In principle it is similar to appliances using mirrors, but instead employs plates of plaster of Paris, with a white matt surface, spaced on a circle at such intervals as to correspond with zones of equal area. The lamp to be tested is placed at the centre of the circle, through which the axis of the photometric bench also passes, direct light from the lamp being screened from the photometer. The photometer thus receives the summation of the diffusely-reflected light from the series of white surfaces, which is a measure of the total flux of light. The apparatus is calibrated by inserting a lamp of known mean spherical candle-power (or lumens) in the usual way. One advantage of using white diffusing surfaces instead of mirrors is that the dimensions of the source are of small importance, and the apparatus can thus be of moderate diameter and yet be applied to lamps surrounded by globes, reflectors, etc. The distance of the photometer can also be varied (though naturally the constant would be altered by so doing).

Mean hemispherical candle-power, or flux of light in one hemisphere only, can be measured by eliminating one set of surfaces; candle-power in a single direction by removing all but two.

*_Elektrotechnische Zeitschrift_, June 27, p. 253.

## REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

*"Works Lighting." By D. H. Ogley, B.Eng. (Iliffe and Sons, Ltd., London; 134 pp.; 64 illustrations).*

In his book Mr. Ogley has contrived to give a considerable amount of useful information on lighting in a relatively small space. We gather that the book is based on a series of articles recently contributed by the author to the *Automobile Engineer.* Professor E. W. Marchant contributes a preface in which he emphasises the importance of the subject, and refers to the work of the Illuminating Engineering Society in this country, and throughout the book frequent reference is made to the Report of the Departmental (Home Office) Committee on Lighting in Factories and Workshops.

In his first introductory chapter Mr. Ogley refers to the effect of illumination on safety, output, and cost of production in order to show that good lighting *pays.* Subsequently there is a summary of the main characteristics of good lighting, and sections devoted respectively to gas, oil, and electric lighting, in connection with which some of the chief methods of arranging lamps are illustrated. A short chapter is devoted to the measurement of illumination and the choice of reflectors, and there is a final treatment of daylight problems in which some sound advice is given. While many of those constantly concerned with industrial lighting problems will naturally wish to go somewhat more deeply into the subject than is possible in a work of this size, we think that Mr. Ogley's book will serve as a good introduction for anyone wishing to get a grip of the chief essentials of the subject. The book is fully illustrated and contains an adequate index.

*"Technology," the Journal of the Manchester Municipal College of Technology. Vol.* IX. (1915).

We have received a copy of the above journal (Vol. IX.) which contains an interesting series of communications presented by students and members of the staff during 1915. Of special interest is the paper on "Education and Industry," which was read by the Principal, Mr. J. C. Maxwell Garnett, before the British Association in that year. The paper discusses the types of education desirable for different kinds of workers in industry, from the unskilled labourer up to the managers and higher technical men, the whole course of their training during 27 years being graphically represented. Among other communications we can only mention a few that strike us as of special interest, namely, those by Professor A. B. Field on "Some difficulties of design of high speed generators"; on mutual induction between masses, by Professor Miles Walker and Mr. W. W. Stainer, and on machine photogravure by Mr. R. B. Fishenden. Other papers deal with various engineering, textile, and chemical problems and serve to show the great variety of work done at the College.

We have also to acknowledge the prospectus of the courses at the College for the session 1918-1919, which again serves to emphasise the valuable nature of the work that is going on.

*"Agricultural Research in Australia." Bulletin No. 1, published under the authority of the Executive Committee of the Advisory Council of Science and Industry to the Commonwealth of Australia.*

This contains a most useful record of Agricultural Research. Those interested in the subject should apply to the Secretary of the Advisory Council (314, Albert Street East, Melbourne, Australia).

*Iron and Steel Institute.*

A very useful series of papers, read at the autumn meeting of the Iron and Steel Institute, has recently been issued. Most of these deal with metallurgical questions such as the qualities of iron and steel as affected by various ingredients and processes, and there are notes on the construction of open hearth furnaces and the testing of refractory materials. A short paper of considerable optical interest, by Mr. A. F. Hallimind, deals with telescopic focussing apparatus for photomicrography.

*County of London Royal Engineer Volunteers.*

We have received the booklet recently issued by the County of London Royal Engineers Volunteers, whose headquarters are at Balderton Street, Oxford Street, W. The Corps is specially intended for engineers, architects, and members of kindred professions, and the booklet contains an interesting summary of its origin and present work. A special feature is the technical instruction in pontooning, trestle bridging, signalling, the use of explosives and flares, &c. Intending recruits should apply to the Adjutant at Headquarters.

# CORRESPONDENCE.

## FLUORESCENCE AND PHOSPHORESCENCE.

[For previous correspondence on this matter see ILLUMINATING ENGINEER, June, 1917, p. 178; August, 1917, p. 225; February, 1918, p. 62.]

DEAR SIR,

In the course of my criticism of Dr. Sheppard's original letter I submitted a comprehensive theory of luminescence as useful to the subject as the theory of atomic disintegration to radio-activity. Luminescence is the conversion of an acceptable form of energy by an acceptable form of nuclei into light. A subsidiary theory was also given: nuclei are not necessarily pre-existent, but they must be existent at the moment of luminescence. These statements embody the results of eight years' daily research in comparative luminiscence, and I criticised Dr. Sheppard's hypotheses, because they were at variance with my theory. According to him nuclei are only of moment in phosphorescence (persistent photo-luminescence), and their function is as so much impurity or dirt which hinders a reaction, whereas to me nuclei are the very gist of all types of luminescence, including photo-luminescence, whether this be short-time (fluorescence) or persistent (phosphorescence), and their prime function is as the seat of the emission of light, they hinder no reaction; Dr. Sheppard seems to take the word impurity too literally.

When Dr. Sheppard submitted the crystallisation of Calcium Tungstate as an explanation of the luminous response, the nuclei were missing; above all the nuclei crystalline form is the most trans- have to be accounted for. The scheme $CaWO_4 \rightleftharpoons CaO + WO$ accounts for the energy transfer and for the nuclei ($WO_3$); the crystal structure is looked upon as an accidental accompaniment.

Let me take a concrete instance; willemite (manganiferous zinc silicate) can be prepared in three furnaced forms:

(a) A sintered powder amorphous —practically opaque.

(b) A transparent vitreous lump, which may be ground to a fairly translucent powder.

(c) Powdery transparent crystals.

Under ultra-violet excitation, where the absorption is practically confined to the surface, the three varieties are much the same, perhaps indeed the first is the best; we can therefore say that the crystal structure of the third variety is an accidental accompaniment.

From this it follows that in any other case of a crystal, evidence must be produced that crystal structure *qua* crystal structure is relevant to the luminescence. If so, why? Where different crystalline varieties are essentially different individuals, of course different luminescent properties may be exhibited, but this has no bearing on the expression I criticised: " crystal structure is largely responsible for the luminous response."

Dr. Sheppard now confines his remarks to Calcium Tungstate, and no longer looks upon the crystal structure as being largely responsible for the luminous response even in this one case, but as an indication " of development of inner chemical equilibrium—approach to saturation of affinities," and the point arises what bearing has this interpretation of the crystallisation on the luminescence? Leaving this puzzle and reverting to the three samples of willemite, we shall find that the third sample is distinctly the best under X-rays, especially hard X-rays, and the explanation is obvious: the crystallisation form is the most trans-

parent as a screen powder, and as the excitement is by no means confined to the surface, the more opaque the sample the less is the possibility of the internal luminescence being of account; now this is not a case of crystal structure being largely responsible for the luminous response, but a case of transparency assisting the brilliancy of the response where the response is not confined to the surface.

Dr. Sheppard, in his subsequent letter, seems to over-emphasise the importance of spectroscopy; surely the whole of science is at our disposal and not one branch, and the discerning mind is the chief factor rather than the instrument. There is also the question of the preparation of pure Calcium Tungstate. Dr. Sheppard's amplification is interesting, but it affords no evidence of purification unless the thermal treatment be stated, because phosphorescent solid solutions usually require a high temperature for their development. He appears, however, to accept my view as to the nature of the impurity causing the phosphorescence. In introducing fatigue, with a view to showing that photo-luminescence is chemical because fatigue is chemical, it is necessary first to prove that the fatigue is a result of photo-luminescence. Fatigue is indubitably chemical and photo-luminescence is indubitably chemical; but they are concurrent, and hardly related phenomena. For instance, fatigue can be brought about though no luminescence has taken place, and luminescence can be exhibited with unimpaired efficiency over an indefinite period by, say, zinc sulphide under daylight; yet fatigue rapidly results by radium excitation. I will not further debate the mysteriousness of crystallisation, except to say that in the May number of the *Journal of the Chemical Society* Sir Henry Miers states: "There is yet no satisfactory theory of the nature of a crystal"!

The chief interest of Dr. Sheppard's new letter attaches to the following: "I was myself formerly entirely of the opinion that fluorescence and phosphorescence were substantially identical. My doubts on this—and perhaps Mr. Landau may lay them—have arisen less as to the validity than as to the utility of this conception." Dr. Sheppard's doubts seem to be based upon the fact that an impurity imparts phosphorescence to Calcium Tungstate. I think, however, that he misinterprets this case. In the normal cases of solid solutions a trace of impurity induces phosphorescence, but it is absolutely a casual contingency that the solvent (Calcium Tungstate) is itself luminescent. The case is quite normal; it is not a passage from fluorescence to phosphorescence, but a superimposing of phosphorescence upon fluorescence. That we are here dealing with a mixed luminescence can be proved by using the spectroscope, and more clearly in numerous other ways (perhaps the prettiest is the contrast in the action of Ultra-Violet rays and X-rays on impure Calcium Tungstate, in the one case fluorescent in the other phosphorescent).

The validity of the conception he doubts I have proved beyond dispute, by the effect of temperature upon a pure substance—ammonium platinocyanide. This temperature effect is a generality, a contingency absolutely inexplicable by his hypothesis; for instance, he cannot contend that ammonium platinocyanide pure at 0°C. becomes impure at 180°C. Besides the validity I will show the great utility of the conception by using that very generality upon which Dr. Sheppard's hypothesis is founded. Fluorescence is more generally indicated by pure solids, phosphorescence by solid solutions. Now among inorganic substances there are not a great number of pure solids that are photo-luminescent—certain tungstates, a certain molybdate, certain platinocyanides (calling platinocyanides inorganic), certain cadmium salts*, such as

* The powerful luminescence of pure cadmium phosphate was discovered by W. S. Andrews (private communication, Feb., 1918), zinc tungstate, cadmium tungstate, and calcium molybdate by myself (May, 1913).

the phosphate and most double uranyl salts, comprise them all. At ordinary temperatures they are as a class fluorescent; uranyl salts show a phosphoroscope phosphorescence and cadmium phosphate a phosphorescence detectable without instrumental appliances.

It will be noticed that these substances are such that if we conceive of a photo-dissociation, coloured impurities would be yielded—*e.g.*, tungstic oxide, molybdic oxide, platinumcyanide, uranium oxide, cadmium oxide; that is, impurities of a type operative in the ordinary phosphorescent solid solutions. It is also to be noticed that these impurities generated by the photo-energy would be (in the superficial film attacked) of the order of 50 per cent. by weight, whereas the amount of impurity in the ordinary phosphorescent solid solutions is of the order .05 per cent. Now if phosphorescence and fluorescence are substantially identical and one of the decisive factors is abundance of impurity, one might expect that if one could make solid solutions containing large amounts of impurity (solute), phosphorescence would become fluorescence, and if this forecast is verified the conception is not only valid but also eminently useful, and the forecast is in fact verified. I make quite a number of fluorescent solid solutions by finding means to make concentrated solid solutions.

The cases may be summarised:

(1) Pure Solid XY $\rightleftharpoons$ X + Y (nuclei) Fluorescent.

(2) Solid Solution X:Y $\rightleftharpoons$ X + Y (nuclei).

Phosphorescent when Y is a trace;
Fluorescent when Y is large;

not only substantially identical, one might say identically identical. For the sake of brevity I called the nuclei in case (1) " evanescent," in case (2) " permanent," meaning thereby that in the case of pure solids the impurities were only existent while the material was in a state of dissociation; while in the case of solid solutions the impurity was the solute. (The word impurity must not be taken literally: salt water is impure water, but it is not an impure salt solution.) From the miscellany of examples I have given which I have now interpreted and which could be multiplied a hundredfold, it is evident that the " permanent or evanescent nature of the nuclei has little to do with the question " of the time-lag.

Further, neither the dissociation nor the reassociation is the luminescence; they give rise, the former to acceptable nuclei, the latter to acceptable energy, and the latter acting upon the former (energy upon nuclei) is the luminescence. The exciting light is gone for good in bringing about a chemical change, the chemical change in reversing gives up chemical energy. It is as it were a fluke that this energy, owing to a concatenation of circumstances, eventually reappears as light; the one light is not related to the other light. Stokes' Law should be enunciated as follows: " In the absence of a more powerful exciting cause a substance is not able to emit the light which would cause it to luminesce, but if a more powerful exciting cause be present a substance is able to emit light which in other circumstances would cause it to luminesce." Stokes' Law, as worded by Stokes, is really the cause, conscious or unconscious, of the baffling nature of the time-lag to students of photo-luminescence; they have been led to believe photo-luminescence is resonance, or harmonic resonance—like sound upon a musical instrument—and they cannot understand the time-lag at all. This is absolutely a wrong conception, for it is a chemical reaction (which, like all other chemical reactions has a variable time factor) which lags. The original photo-dissociation is possibly a resonance effect, like soldiers marching in step over a bridge causing the bridge to swing right out of its supports, but even if this is so in the photo-dissociation the resonance begins and ends. The photo-dissociation is not

the luminescence; it is inconceivable that the re-association is the luminescence, for a chemical reaction never gives rise to light as a direct effect; it gives rise to energy (call it chemical or electronic) which may eventually appear as sound, light, heat, electricity, or so on according to the nature of the system. If the system that was eventually acted upon by the chemical energy was substantially identical with the absorbing system, this might amount to a resonance effect, but assuredly in photo-luminescence this is just what does not occur. The absorbing centres are not the emitting centres; the very rays that a photo-luminescence substance emit, are just those which it cannot absorb.

I hope that Dr. Sheppard will accept my view, and if, in his rejoinder, he will tell us something about the laws of photo-dissociation, and explain why Calcium Tungstate is photo-luminescent. and strontium tungstate not so, this would be extremely helpful. It is this type of difficulty, essentially of a photo-chemical nature, which baffles me, and it is also a type of problem which makes me doubt that even the photo-dissociation is a resonance effect, because of the enormous range of rays to which Calcium Tungstate is sensitive, and the complete insensitivity of strontium tungstate over this range.

I would add a word of caution. Dissociation is a necessary preliminary to so-called intra-molecular change, and this latter change is not the less complex change. Stokes looked upon intra-molecular change almost as a physical process; it was the Victorian view; it is as well to state that in phototropy there is a chemical basis substantially identical with that in photo-luminescence, but there is no light emission, therefore the photo-dissociation and the re-association is a side issue, it is not the luminescence; it is the disposal of the energy, presumably electronic, in a characteristic manner by characteristic nuclei, which is the luminescence, which is the main issue. This eventual mechanism is the same in all cases of luminescence, and luminescence differs from incandescence, not in the energy which finally comes to bear (for in this latter case it is also presumably electronic), but that in incandescence the disposal is by masses, not by nuclei. True enough the one merges into the other, but the whole of Nature is a merging —" mankind classifies for convenience but Nature knows no boundaries."

—Yours truly,

A. L. LANDAU,
Luminescence Laboratories,
Cold Chemical Co.,
London, N.

## THE TESTING OF SCIENTIFIC GLASSWARE.

ARRANGEMENTS have been made, after consultation with the Ministry of Munitions and the Department of Scientific and Industrial Research, and in conjunction with the British Chemical Ware Manufacturers' Association and the British Laboratory Ware Association, for the testing, at the National Physical Laboratory of Scientific Glassware, etc., on a more comprehensive scale than hitherto.

The tests will include (*a*) volumetric tests of graduated vessels of all kinds; (*b*) tests on the resistance to chemical action and the general suitability of vessels for use in chemical processes; and (*c*) tests on filter-paper, porcelain ware, etc., as used in physical and chemical laboratories.

A scale of fees is appended to the circular referring to the tests, and full instructions regarding the dispatch of articles on test can be obtain on application to the Laboratory. This new departure satisfies a long-felt want and will doubtless be of assistance in promoting uniform excellence of manufacture of such chemical and laboratory glassware.

# TOPICAL AND INDUSTRIAL SECTION.



[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

## THE LUMEN IN PRACTICE.

We have received from the British Thomson-Houston Company a new edition of their excellent little booklet (Handbook No. 1A). It is a revised and fuller edition of their first Handbook No. 1 on incandescent electric lamps. This second edition gives the latest revised Association sales rules, terms, and conditions on incandescent electric lamps, and opportunity has been taken to make this new edition a more complete one in respect to the definitions and terms used in the lamp trade and lighting industry. We note with special interest an article on the "Lumen" as a basis of rating for electric lamps and its method of application in solving illumination problems. The article is written in a popular manner, and special pains have evidently been taken to make the subject matter correct and intelligible. There are four sections dealing successively with the nature of the unit, its derivation and technical definition, its practical advantages, and its application. The last section contains a table of coefficients of utilisation.

A very complete list of photometric units, standards, and definitions is also included. These new units of illuminating engineering should be familiar to all electrical engineers and contractors, as in course of time they will become definite units of the lighting industry, just as the electrical units, the "ampere," "volt," "watt," &c., have become known to and used by the electrical trade. This handbook is issued for the use of the electrical trade and electrical engineers, and copies can be obtained from the Lamp and Wiring Supplies Department at Mazda House, 77, Upper Thames Street, London, E.C. 4.

The inclusion of the data relating to the lumen marks an enterprising departure, and shows how leading firms concerned with lighting are applying and bringing into practical use the scientific methods which have been developed since the inception of the illuminating engineering movement in this country.

## WARDLE "ALL-BRITISH" FITTINGS.

A LEAFLET issued by the Wardle Engineering Co., Ltd. (Manchester), is devoted mainly to industrial lighting units for half-watt lamps, giving various conditions of light-distribution. A polar curve from a 1,000 c.p. "half-watt" lamp, in a special "Primus" lantern giving a high component at angles of 15° to 20° below the horizontal accompanies the leaflet.

## PUBLICITY AND THE GAS INDUSTRY.

A LETTER from Mr. Goodenough, the Chairman of the Executive of the British Commercial Gas Association, to a recent issue of the *Gas Journal*, emphasises the great importance to the gas industry of steady propaganda, of the type carried out by the Association. At a time like the present, when consumers are called upon to adjust themselves to new and unprecedented conditions, and when "give and take" between the public and companies supplying gas is essential, the value of the good relations established with such patience during recent years is strikingly illustrated. Any new departure is rendered much easier to carry out when once a friendly feeling has been established.

In the future new problems will arise and the experiences of the war will be repeated. Indeed, the cultivation of a conviction on the part of the public that the company is there to do good service, to help the consumer by advice and guidance, and to work with him for the benefit of both parties will prove one of the most useful assets any company could possess.

In this direction the enlightened policy of the Association, in maintaining and even extending their publicity arrangements during the war, will bear good fruit in the future, and is doubtless fully justified in its bearing on present circumstances. Mr. Goodenough traces a great change for the better in the public attitude towards gas companies during the past twenty years—an improvement which is rightly ascribed to the constant spade-work that has been done during this period in removing misconceptions and fostering good relations.

### GAS RATIONING IN GERMANY.

We observe that in Berlin the prescribed economy to 80 per cent. of the 1916 amount of gas has not been attained. Unless an improvement is effected in this respect the authorities contemplate fixing certain "gasless" hours, *i.e.*, periods during which no gas will be supplied.

## BLAND LIGHT SPECIALITIES.

A feature of the exhibit of the Bland Light Syndicate at the British Scientific Products Exhibition was the series of burners of the porcelain type. One series of twelve were of of the patent porcelain universal type with combined Bunsen tubes and nozzles, while six others served to show the use of the special porcelain shells, by which the products of combustion are deflected, thus avoiding contamination of the primary air supply. We understand that these porcelain fittings were already being entirely manufactured in this country before 1914, but the shortage of metal has naturally been a circumstance favouring their wider use since the outbreak of war. The porcelain fittings have also the advantage that they are not subject to corrosion in the same way as metal, and, as the coloured illustrations in the firm's literature show, they lend themselves readily to tasteful effects.

In a recent visit to the showrooms of the firm we also noticed several attractive forms of shades for use with such burners, including a diffusing glass cylinder in imitation of a lantern, suitable for domestic use in a hall, etc.

Another novelty in the exhibit was the 300 c.p. low pressure three-burner lamp, in which important improvements have been made, rendering unnecessary the small inner globe previously employed. In view of the difficulty in obtaining adequate supplies of such heat-resisting inner globes their elimination is a distinct advantage.

### PERSONAL.

Mr. J. E. Edgecome, Borough Electrical Engineer, Kingston-on-Thames, has been appointed director of the Tungsten Lamp Association. Mr. Edgecome was one of the first engineers of electric supply companies to become a member of the Illuminating Engineering Society and his wide experience of lighting problems should prove of great value to the Association. We wish him every success in his new work.

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## LIGHT AND FUEL ECONOMY.

### CONTROL OF PARAFFIN, WOOD AND CANDLES.

We understand that further Orders are being prepared dealing with economy in light and fuel. An order regulating the consumption of paraffin in course of preparation will prohibit the use of this commodity for lighting and heating in houses where gas or electricity are available. Another Order is to deal with the sale and distribution of wood for fuel, and in areas where wood is plentiful consumers may be required to take part of their ration in this form, two tons of wood being regarded as the equivalent of one ton of coal.

We also understand that the control of candles will be taken over by the Ministry of Food, by arrangement with the Board of Trade, similar action being taken in regard to soap.

With respect to candles it is expected that the Coal Controller will issue regulations as to the disposal of stocks with a view to ensuring proper distribution to miners.

### LIGHTING CURTAILMENT IN CINEMA THEATRES.

It will be recalled that in March last the compulsory closing of cinema theatres after 10.30 p.m. was called for in the Order issued by the Board of Trade, and this has no doubt had the effect of bringing about a reduction in the consumption for heat, lighting, and power. The present emergency, however, may compel a further diminution in consumption, and we understand that the Controller of Coal Mines has in view the rationing of lighting and heating of cinema theatres. Meantime the Cinematograph Exhibitors' Association has impressed on all its members the need for rigid economy in theatre-lighting.

## BLANCHARD BRITISH LAMPS.

Among the lighting exhibits at the British Scientific Products Exhibition, the portable outfit for lighting camps, hospital tents, etc., shown by Messrs. Blanchard (British) Lamps, Ltd., is of special interest. These lamps utilise oil or paraffin in conjunction with special incandescent mantles, and are quite easily started by a small charge of methylated spirit. Being essentially portable, they lend themselves well to many kinds of Army work, as they can be transferred (while lighted) to any place where light is wanted, and give an exceptionally high candle-power for lamps of this class.

A feature of interest is the use of an exceptionally strong mantle with these lamps, which is stated to last on the average for about 500 hours. Another element of considerable importance is the "pricker," a device which enables the jet orifice to be conveniently kept clear.

Fig. 1 shows a typical 300 c.p. model, weighing when full 12lb., and 26in. overall dimensions, while Fig. 2 shows a tripod arrangement capable of raising lamp 9ft. above ground. As an alternative arrangement, the lamp can be suspended over a pulley attached to a tent pole. The hospital outfit (shown at the Exhibition) is packed away in a box of quite moderate dimensions.

FIG. 1.—TYPICAL BLANCHARD PORTABLE LAMP FOR INDOOR OR OUTDOOR USE (300 c.p.).

FIG. 2.—LAMP ARRANGED ON STEEL TRIPOD AT HEIGHT OF NINE FEET.

## CONVERTING CENTIGRADE TO FAHRENHEIT.

A small leaflet issued by the Cambridge Scientific Instrument Co., Ltd., illustrates a very simple chart adapted to the conversion of temperatures from Centigrade to Fahrenheit. In order to secure the maximum utilisation of space the chart is printed in the form of a spiral on a varnished card measuring 12in. by 14½in. The chart covers a range from—273°C. to 2,000°C., and supplementary tabular data on standardising points, melting points, specific heats, etc., are entered in the available free space in the corners of the card.

# 9

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# EDITORIAL.

### A British Institute of Industrial Art.

The application of science to industry has been the subject of constant discussion since the outbreak of war. At the meeting held at the Royal Society of Arts on October 28, at which Mr. H. A. L. Fisher, President of the Board of Education, presided, a new departure—an Appeal for the Promotion of Industrial Arts—was announced. The appeal is for the encouragement of two distinct movements. The Industrial Arts Committee of the Royal Society of Arts (representative of the Arts and Crafts Exhibition Society, the Design and Industries Association, the London County Council Consultative Committees on Silversmithing and allied trades, Book Production, Furnishing, &c.) has prepared a scheme in which arrangements for better educational facilities formed a prominent feature. Independently, a scheme for the establishment of a British Institute of Industrial Art was being promoted under the joint auspices of the Board of Trade and the Board of Education, the principal feature being the establishment of a British Institute of Industrial Arts, including a permanent exhibition in London of modern British works of artistic merit.

According to the joint appeal made for the two schemes, the exhibition is to be organised at the Albert Museum, and a central fund raised to initiate and encourage research, to provide travelling scholarships for

designers, buyers, salesmen, &c., and to develop propaganda work. The scheme was well received in the discussion in which Lord Leverhulme, Sir William McCormick, Sir Frank Warner, Sir Charles Allom, Mr. Gordon Selfridge, and others took part. It was pointed out by Sir William McCormick that the scheme ran on parallel lines to the work of the Department of Scientific and Industrial Research, and that there were many industries in which scientific research and artistic creation must necessarily work hand in hand. Similarly the proposed exhibition may be regarded as complementary to the British Scientific Products Exhibition, doing for Art what the latter exhibition is intended to do for applied Science.

The interlinking of this movement for the improvement of industrial art with scientific research is an important feature, and we are glad to note that provision for interchange of experience will be made. Since the war, Industry and Science have drawn closer together; Art should keep in touch with both. In the field of Illuminating Engineering we see a particularly favourable field for the union of these three elements. At the moment we have naturally been concerned mainly with the industrial applications of illumination, but there is no doubt that in the future the æsthetic aspects will receive an increasing amount of attention. There seems no reason why lighting fittings should not be made more beautiful without undue sacrifice of efficiency, and there is a great opportunity for the craftsman who unites with artistic perception a knowledge of how light can be directed with the minimum absorption and waste. There is abundant scope for effort in the improvement of both indoor and outdoor lighting fixtures. Street-lamps are at present far from beautiful objects, and a great deal could be done to make our streets more attractively as well as more efficiently lighted at night. We trust therefore that illuminating engineering will be made an integral part of the scheme, and that the reconciliation of artistic merit with practical efficiency in lighting fittings will be made one of the subjects for study.

There is one aspect of the same scheme, referred to in the discussion by Mr. Gordon Selfridge, that deserves attention. It may be, as Mr. Fisher said in his introductory address, that there has been a tendency to depreciate the degree of artistic craftsmanship available in this country; and that works of art, if made readily accessible, will find a readier welcome than is commonly supposed. Yet experience shows, however, that in any campaign of this kind patient educational propaganda are necessary to final success. This has been the case in scientific and industrial research; it has also been our experience in the illuminating engineering movement. The public must be taught to appreciate beautiful things. As Mr. Selfridge pointed out, manufacturers cannot undertake to make articles of high artistic merit, unless they are confident that they can be sold. It is necessary to create the demand by steady educational effort, spread over a number of years. The new scheme should be assured of support for a sufficiently long period to enable it to " make good." It is right that the public and the industries concerned should be invited to co-operate. Education, however, is a matter for the nation, and we think that the necessary basis of permanent security should be provided by the State.

### The Advantages of Good Machine-Shop Lighting.

Since the outbreak of war we have often had occasion to emphasise the benefits of proper industrial lighting as a vital factor in national production, and we notice that the same point is being strongly emphasised in the United States. An informing series of articles on the lighting of different classes of industrial establishments by Mr. F. H. Bernhard has been appearing in the *Electrical Review* and *Western Electrician*, and the first of these, devoted to machine-shop lighting, fully endorses the main advantages of good illumination which are familiar to our readers. We may, however, quote once more these advantages which are summarised under eight headings, namely:—(1) Reduction of accidents; (2) Greater accuracy in workmanship; (3) Increased production for the same labour cost; (4) Less eye-strain; (5) Better working and living conditions; (6) Greater contentment of the workmen; (7) More order and neatness about the plant; and (8) Supervision of the men made easier.

What is chiefly needed now is concrete evidence in support of these facts. We have previously estimated the percentage cost of lighting to be very small, sometimes less than 1 per cent. of the total cost of production. Mr. Bernhard confirms this by an analysis of the costs of production in a machine-shop. Taking the total cost of production at an arbitrary figure of 100, labour and material were respectively proportional to 31 and 38, and overhead charges 28, power only 2.7, and lighting only 0.3. The cost of lighting was thus well under one per cent. of the total cost of production, and it is quite evident that a small increase in expenditure on lighting necessary to secure adequate illumination, say 20 per cent., would scarcely affect the total cost of production, and yet might very materially affect the value of the output.

From cases which have come under his notice, he finds that the gain in output following a judicious improvement in lighting commonly ranges between 2 and 10 per cent., although in certain cases a very much larger increase has resulted. Thus he quotes the case of a Chicago machine shop where, in various departments, increases of from 8 to 27 per cent. was secured, the mean gain being 15 per cent. Even more striking is the case of a factory devoted to the making of concrete mixers. In this case a good comparison was possible, because half the shop was first converted to improved lighting, rendering possible a contrast with the other half lighted under the old conditions. It is significant that the workers in the unconverted half of the works soon clamoured for the same improvement as that enjoyed by the remaining workers, and it appears that their claim was fully justified by the contrast in the results obtained respectively under the old and new lighting conditions. It was found that with better lighting 5 machines could be turned out in the time formerly necessary for $3\frac{1}{2}$—a gain of 43 per cent.

Such instances of the economic advantages of good lighting are very helpful, and we hope that when the war is over there will be records of a similar kind to substantiate the benefits of good lighting in many of the factories in this country.

### The Industrial "Safety First" Movement.

We have repeatedly had occasion to refer to the important "Safety First" movement that has developed in this country since the outbreak of war, and has justly received wide recognition both by manufacturers and Government officials. Readers will recall that a resolution in favour of the formation of a National Safety First Movement was adopted unanimously at the Industrial Safety First Conference, held at the Mansion House, on June 12th. On October 31st the first Council meeting was held, and the movement crystallised in the formation of what is now to be termed the "British Industrial Safety First Association."

In order to realise what the application of "safety first" principles in factories may accomplish, it is only necessary to recall that in the year 1914, 969 persons were killed and 147,045 persons injured in the factories and workshops of this country, and these figures would have to be largely increased if accidents in streets, on railways, and in mines were also taken into account. This fact is brought home in a recent memorandum issued by the Home Office Factory Department, in which an account is given of the experiences of a firm in the North of England, which has pursued an active "safety first" campaign. Among the steps taken importance must be attached to the formation of Accident Enquiry Committees, on which both management and staff were represented, and through their efforts in a single year the number of accidents in the works has been reduced by more than 50 per cent.

The memorandum remarks that it is no use merely *telling* workers to be careful. They must be shown by actual demonstrations how to avoid accidents; they must be convinced that their employers are in earnest about the matter, and that their co-operation is essential and will be sympathetically received. It is here that the newly-formed British Industrial Safety First Association steps in. It provides a centre for this unofficial effort, creates machinery for enlisting the active help of both employer and employee, and provides a means of pooling the experience of factories throughout the country. The industrial "safety first" movement thus ranks high among measures of reconstruction.

Among the other factors responsible for accidents the effects of inadequate lighting will receive study, and the Illuminating Engineering Society is appropriately represented in the new Association. It will be recalled that in the National Museum of Safety, which was designed and built shortly before the war, and will, we hope, be equipped in the near future, a special section was to be devoted to lighting. This will provide an opportunity of showing, by photographs, sketches, and models, how accidents due to insufficient or poorly arranged lighting are caused. Safety officers, and committees charged with regular inspection of works, should include the examination of lighting arrangements among their own duties; and insurance companies, recognising that better illumination diminishes appreciably the risk of accidents, should find in the new movement fruitful opportunities for their co-operation.

LEON GASTER.

# THE REQUIREMENTS OF AUTOMOBILE HEADLIGHTS

REPORT OF A COMMITTEE OF THE ILLUMINATING ENG. SOC., U.S.A.

A very comprehensive report on automobile headlamps has been prepared by the Illuminating Engineering Society in the United States, and appears in the last issue of the Transactions.* The report comprises five sections: (1) Introduction, giving a general outline of the headlighting problem, (2) Requirements of Vision (requisite road-illumination, avoidance of glare, &c.), (3) Optical Principles of Headlights, (4) Practical Headlighting, and (5) Safety Limitations.

It is remarked that the conditions desired respectively by driver and pedestrian are to some extent in conflict. Adequacy for safe driving is determined by the discriminating ability (sensibility to contrast) of the driver, safety for others by the amount of success in eliminating glare from headlights. A driver requires a powerful beam in order to see objects on the roadway, and it is almost inevitable, especially on a very dark road, that the brilliancy of such lights should prove inconvenient to pedestrians to some extent. One must therefore effect the best compromise possible. Requirements of safety must be carefully distinguished from mere comfort or personal preference. It is felt, however, that the existing regulations controlling headlights in various States leave something to be desired. (Some observers hold that present-day driving in districts where the most stringent legislation is in force is little, if any, safer than at times and places where no corrective devices are used!)

The requirements of vision are very carefully considered in the report, data being presented relating to brightness, "discrimination factor" (*i.e.*, capacity to observe contra) and glare limit. It is deduced that for ideal lighting the brightness of the roadway should be a maximum (at least 0.01 millilamberts*) over an oblong area covering nearly the width of the roadway and a length from 50 to 100 feet ahead of the driver. From this area of maximum brightness the illumination should gradually diminish. From the point of view of the pedestrian the illuminating beam should never fall in his eyes, and he should not be exposed to more than about 100 c.p. for a time greater than half a second. These conditions are, however, difficult to secure. The brightness of sources used for headlights may be 500-1,500 lamberts, which is hundreds of times the limiting brightness of 0.4 lamberts for an eye adapted to a road-brightness of 0.01 ml. To avoid glare completely would mean cutting down the light by a factor of 1,000, which is quite impracticable. The most hopeful device is thus to limit the beam so that it rarely enters the observer's eye, and it may also be noted that a higher road-illumination, by relieving the contrast, is an aid to mitigation of glare.

Even when the beam has been directed at a suitable angle below a prescribed horizontal plane, so that it does not ordinarily enter the observer's eye, the effect of irregularities in the road, which may easily tilt the beam by 1 or 2 degrees, must be considered. This, however, is not of great moment, as the effect is only momentary. A more serious difficulty is the variation in inclination of the beam due to shifting load. Someone entering or leaving the rear of the vehicle will change the inclination of the headlight by 1-2 degrees in most automobiles. The only thing possible is to adjust for average load distribution, and corresponding average tilt of beam.

The most important section of the report is the final section in which the general safety limitations are stated.

In what follows we give a summary of these recommendations:

*Transactions of the Illuminating Engineering Society, U.S.A., July 20, 1918.

*For practical purposes 1 millilambert may be regarded as equivalent to 1 foot-candle surface brightness.

**Nature of Beam.**—No headlight should be permitted such that the reflected or beam light is projected above a plane 42 in. above the road and parallel to it, measured 100 ft. ahead of the vehicle. No limitation is imposed to the lateral spread of the beam provided it is kept below this level.

**Scattered Light.**—No light is tolerated which at 5 ft. above the road surface is more than a certain candlepower. The practical limit is of the order of 100-500 c.p., 1 degree above the horizontal or 5 feet above road level at 150 ft. distance. The exact limit is left for further consideration.

**Minimum Road-Illumination and Width of Beam.**—No driving is to be permitted where the road illumination is less than 0.001 ft. candles. The normal illumination provided at distances from 50 to 100 ft. ahead of the vehicle should not be less than 10ft. in width upon the road surface. No regulation regarding the colour of headlights is suggested.

### REGULATIONS OF THE STATE OF NEW YORK.

We have also been favoured with a copy of the Act which came into operation on May 8, 1918, bearing on the lights of motor-vehicles.

It is directed that: "Every motor vehicle, driven or operated upon the public highways of the State during the period from one half-hour after sunset to one half hour before sunrise, shall display when running at least two lighted lamps at the front, one on each side of approximately equal power, not exceeding 24 c.p., and one lighted lamp on the rear of such vehicle, which shall also display a red light visible from the rear. The rays of such rear light shall shine upon the number plate carried on the rear of such vehicle in such manner as to render the numerals thereon legible for at least 50 feet in the direction from which the motor vehicle is proceeding. The front lights shall be so arranged, adjusted and operated as to avoid dangerous glare or dazzle, and so that no dangerous or dazzling light, projected to the left of the axis of the vehicle when measured seventy feet or more ahead of the lamps, shall rise above forty-two inches on the level service on which the vehicle stands. They shall also give sufficient side illumination to reveal any person, vehicle or substantial object ten feet to both sides of said vehicle, at a point ten feet ahead of the lamps. If, in addition to headlights, any vehicle is equipped with any auxiliary light, projecting device or devices, other than the rear light, such auxiliary lights shall be subject to all the restrictions of this section."

It is further specified that the front lights shall be visible at least 250 feet in the direction in which the motor vehicle is proceeding, and if the street lighting is not sufficient to reveal any person, vehicle or substantial object at a distance of at least 200 feet, then the front lights must be sufficient to do so. Motor trucks, of two tons capacity or over, governed mechanically or so constructed that the speed cannot exceed 15 miles per hour, must be visible at a distance of 200 feet, and sufficient to reveal any person, vehicle or substantial object at a distance of 75 feet.

Particulars are also given for the procedure to be adopted by any person desirous of submitting any headlight arrangement for test and approval.

### SPECIFICATION FOR HEADLIGHT TESTS.

A specification for headlight tests stating the general conditions of acceptability, gives detailed particulars of the nature of laboratory tests, the nature of the samples, and the types of reflectors required.

The general conditions are stated as follows:

(1) Any pair of headlamps under the conditions of use must produce a light which, when measured on a level surface, on which the vehicle stands, at a distance of 200 feet directly in front of the car and at some point between the said level surface and a point 42 inches above this surface, is not less than 1,200 apparent c.p.

(2) Any pair of headlamps under the conditions of use shall produce a light which, when measured at a distance of 100 feet directly in front of the car, and at a height of 60 inches above the level surface, on which the vehicle stands, does not exceed 2,400 apparent c.p., nor shall this value be exceeded at a greater height than 60 inches.

(3) Any pair of headlamps under the conditions of use shall produce a light which, when measured at a distance of 100 feet ahead of the car, and 7 feet or more on the left of the axis of the same, and at a height of 60 inches or more above the level surface, on which the vehicle stands, does not exceed 800 apparent c.p.

Detailed instructions are given as to the manner of testing the lamps in a dark room, with a white surface at a testing distance of not less than 60 feet nor more than 100 feet. The intensity is to be measured with each pair of samples in turn and with either of the following types of incandescent lamps:

(1) Vacuum type 6-8 v. 17 m.s.c.p., G-12 bulb.

(2) Gas-filled type 6-8 v. 20 m.s.c.p., G-12 bulb.

Lamps are to be adjusted to give their rated c.p. Two pairs of samples are to be submitted for test, one to be retained for future reference.

## THE CANDLE-POWER OF AUTOMOBILE HEADLIGHTS.

An article by Mr. L. C. Porter which appeared in the *General Electric Review* (U.S.A.) for September forms a useful supplement to the report by the Committee of the Illuminating Engineering Society, U.S.A., and other data, summarised above.

Mr. L. C. Porter gives a useful summary of anti-glare devices, the most efficient of which involve special design of lens and reflector with a view to shaping the beam. Devices applied to the bulb itself, or resistance to reduce the candle-power, are only of secondary value. Some useful curves are presented, based on railway tests, showing the candle-power necessary to enable a man in light or medium dark clothes to be "picked up" at different distances. Generally speaking, a man in dark clothes can be distinguished at 1,000 feet distance with 10,000 c.p.; while with ten times the light the distance is nearly doubled.

The beam-candle-powers of typical headlights 10in. diameter with 21 c.p. lamps approach 50,000, which anti-glare devices may lower by 25-90 per cent. according to type. Correct focussing is very important. A deviation of 1/16in. from focus reduces the maximum light to 31 per cent., while with 1/4in. displacement only 4 per cent. of the maximum beam-candle-power remained.

## TESTING ILLUMINATION BY OBSERVATION OF TYPE.

The primitive method of testing illumination by observing the distance at which fine type can just be read is doubtless a very rough and ready device in comparison with an illumination photometer. Such devices are open to the objection that they depend very greatly on the eyesight of the observer, and on the careful selection of type. Up to a certain point the distance at which letters of known size can be read increases rapidly with the intensity of the light, but when the intensity exceeds a certain value the increase in distance is small. The method appears to have been revived in a somewhat new form by Prof. T. A. Lundbye, who, in a recent contribution before the Society of Danish Engineers, described a process which only requires a pair of smoked glasses and a measuring scale. The distance at which a certain type can be seen with the naked eye is noted, and then the corresponding distance when a pair of smoked glasses is placed in front of the eyes. The ratio of these two distances is said to give a measure of the intensity of the light.

## A NEW METHOD OF MARKING AND LIGHTING SAFETY-ISLANDS IN STREETS.

The increasing volume of fast traffic has led to the use of " safety-islands " in large thoroughfares of most great cities, especially at busy junctions where several streets converge. The proper method of indicating such islands to drivers has been the subject of much discussion in the United States. The need for a satisfactory marking and lighting device is evident when one considers the large proportion of accidents that occur at such spots, and an investigation of the matter has recently been conducted as an outgrowth of the safety work of the Bureau of Mines, Washington.

The results of this investigation are summarised in a recent issue of the *Electrical Review and Western Electrician*. The design commonly used hitherto consists of a stanchion with a red globe 6 to 10 feet above the roadway. This is regarded as an unsafe design because most automobile drivers watch the roadway to prevent collisions with other vehicles or avoid any obstructions. Consequently a poorly-lighted or inconspicuous red globe at a height of 6 to 10 feet may fail to be recognised until too late. An improvement has been made by also placing alongside the stanchion and near its base one or more red lamps of smaller size in water-tight fixtures; these lamps being additional to the large red globe at the top.

A new and improved design has now been developed by the Illuminating Engineering Department of the Bureau of Mines. This design is intended firstly to mark definitely the intersections of streets and direction of traffic both by night and day, and, secondly, to minimise loss of life and damage to property. The new device is mounted only slightly above the level of the street, and is of sufficient size to be readily distinguishable either by night or day. The top of the casing is only 12 inches above the road level. The casting is mounted on a concrete base in such a manner that if the impact of a motor vehicle with it is of sufficient force the casting will be lifted from its seat and slide forward, thus minimising serious consequences of collision; at the same time it is sufficiently firm to prevent wilful interference and discourage deliberate running over it. Owing to its position the device will be always in the line of vision both by night and day.

The iron casting has a series of radial slots through which a red lamp in the centre is visible from any direction by night, and this slotted portion is painted red so as to be readily distinguishable by day. From the top point the surface slopes down to the outer circumference so that water will run off it.

## A POLARISATION METHOD OF PRODUCING " ARTIFICIAL DAYLIGHT."

Methods of producing " artificial daylight " have hitherto been based on subtractive devices, *i.e.*, on the use of special coloured screens which transmit rays giving light that closely resembles natural daylight in colour. According to an article by Mr. I. G. Priest in the *Physical Review* this result can be secured with greater perfection by the use of two crossed nichols in conjunction with a quartz plate. It is claimed that by this method a more accurate resemblance to daylight can be secured, and in particular that the distortion due to a sharp maximum near 0.57 $\mu$ which is almost invariably found in colour-screens, is avoided. The conditions are exactly reproduceable, and by slightly varying the angle between the nichols the colour can be varied to reproduce more exactly certain forms of daylight (*e.g.*, diffused light from white sky, direct sunlight, etc.). The method is not regarded as a competitor of screen methods for lighting large surfaces, but appears promising where great accuracy is needed, and it is only necessary to illuminate a small area.

# A NEW INDUSTRIAL LIGHTING CODE IN WISCONSIN (U.S A.).

It is interesting to observe that the State of Wisconsin, which was one of the first in America to adopt legislation on factory lighting, has recently issued a modification of the original "code" in which the procedure is brought up to date. Its provisions are summarised in a recent article by Mr. J. A. Hoeveler in the *Electrical World*.

The new code is based largely upon that drafted by the Illuminating Engineering Society in the United States, and resembles that adopted in other States. The original recommendations were considered to need revision chiefly because (1) insufficient distinction was made between the requirements of different classes of work, (2) the requirements in some cases were too low, and (3) the requirements were indefinite in that in some cases they did not specify a particular order of illumination, leaving the selection to the employer. In the present code the illumination for various classes of work is set out as follows:

ILLUMINATION INTENSITY AT THE WORK IN FOOT CANDLES.

| | Minimum Permissible Intensity. | Ordinary Practice. |
|---|---|---|
| (a) Roadways and yard thoroughfares ... ... ... ... | 0.02 | 0.05—0.25 |
| (b) Storage spaces ... ... ... ... ... ... ... | 0.25 | 0.5 —1.0 |
| (c) Stairways, passageways, aisles ... ... ... ... ... | 0.25 | 0.75—2.0 |
| (d) Toilets and washrooms ... ... ... ... ... ... | 0.5 | 1.5 —3.0 |
| (e) Rough manufacturing, such as rough machining, rough assembling, rough bench work, foundry floor work ... | 1.25 | 2.0 —4.0 |
| (f) Rough manufacturing involving closer discrimination of detail | 2.0 | 3.0 —6.0 |
| (g) Fine manufacturing, such as fine lathe work, pattern and tool making, light coloured textiles ... ... ... ... | 3.0 | 4.0 —8.0 |
| (h) Special cases of fine work, such as watch-making, engraving, drafting, dark-coloured textiles ... ... ... ... | 5.0 | 10.0—15.0 |
| (i) Office work, such as accounting, typewriting, etc. ... ... | 3.0 | 4.0 —8.0 |

Note.—The measurements of illumination are to be made at the work with a properly standardised portable photometer.

Another interesting feature in the requirements is that lamps suspended at elevations above eye-level less than one-quarter their distance from any position in which work is performed, must be so shaded that the brightness does not exceed 75 c.p. per square inch; lamps suspended at greater elevations than 20 feet need not comply with this requirement, but units used for local lighting must not exceed 3 c.p. per square inch in brightness. A proviso is made that overhead lighting must be supplementary to local lighting in order to avoid objectionable shadows and sharp contrasts in brightness; but here, again, an exception is made in cases where the light from local lamps falls chiefly on surfaces which are white, or nearly so, and which by reflection may give sufficient general illumination.

Special stress is laid on the desirability of maintenance, and while reasonable latitude is allowed in imposing regulations on this point, it is suggested that inspectors should have authority to order a general clean up when the conditions of lighting in this respect are obviously poor. The extension of the duties of inspectors, who now do considerable educational work in advising foremen and men how to avoid accidents, etc., will doubtless enable them to give effective advice on maintenance of lighting amongst other matters tending to the welfare of employees.

The Code came into effect on the 1st of July, and arrangements were made to issue an appendix to the bulletin comprising the code giving hints to architects, contractors and superintendents of factories how best to comply with its requirements.

## EXPERIMENTS ON THE HARCOURT 10-C.P. STANDARD PENTANE LAMP.

The constants employed to correct the candle-power of the 10-c.p. Pentane Standard have been determined with great exactitude. As regards the correction for barometric pressure there appears little room for doubt, as the values obtained by Paterson, Trotter, and others are in close agreement on this point. But in regard to the effect of water-vapour some divergency of results has been recorded, the correction obtained by Rosa and Crittenden at the Bureau of Standards being consistently lower than that obtained in this country (0.0057 as compared with 0.0063).

An investigation on this point was carried out by K. Takatsu and M. Tanaka, of the Electrotechnical Laboratory in Department of Communications, Tokyo, last year, and a very careful series of tests gave good agreement with the figure obtained at the National Physical Laboratory. Since the climatic conditions in Japan resemble those in England rather than the United States, this result gives colour to the suggestion that the differences recorded at Teddington and Washington are essentially due to the climate variation.

There is, however, another circumstance mentioned by K. Takatsu and M. Tanaka, namely, that at the Bureau of Standards a ventilating duct is used above the lamp to carry away the products of combustion, while at the National Physical Laboratory and in Japan no such duct is used. It appears possible that the use of the duct may have an appreciable effect on the water-vapour correction. There is another drawback to this device, namely, that it appears to have a depressing effect on the candle power. This, at least, was found to be the case in Japan, and the conclusion is supported by the fact that some tests of English and American lamps, recorded by Rosa and Crittenden, have given results which were abnormally low, *i.e.*, 9.58—9.89 c.p. The point is of some importance as the use of such a duct with the Pentane Lamp would have the effect of lowering somewhat the value of the international candle, as derived from the Pentane 10-c.p. Standard. As ordinary measurements with the 10-c.p. standard are made in ten minutes and less, it seems unnecessary to provide special appliances to carry off the waste gases if doors and windows are thrown open so as to allow fresh air to circulate for half an hour before the experiment.

## LUMINESCENCE DUE TO RADIO-ACTIVITY.

A contribution by E. Karrer and D. H. Kabakjian to the Journal of the Franklin Institute (Sept., 1918) contains an account of a variety of interesting experiments on radio-active substances, both by themselves and when utilised with a luminescent base (such as zinc sulphide).

The authors confirm the impression that after the luminescence of zinc sulphide has been decreased with age there is no known method of rejuvenating it. Radium bromide, however, can be rejuvenated by heating, and the same applies to some extent to barium platinocyanide after becoming exhausted after X-ray bombardment.

The authors discuss in detail the effect of heat on radio-active substances in causing a transitory " flash-up " in brightness, which, however, is followed by total decay as the heating continues. But on slowly cooling to room-temperature the original brightness is restored. The suggestion is made that ultimately materials of this class may prove to have useful applications in illumination-photometry and also for pyrometric work. So far as the latter suggestion is concerned it must, however, be borne in mind that the peculiar colour of the light emitted by phosphorescent substances and the low illumination at which measurements would have to be made are decided drawbacks.

# THE INFLUENCE OF QUALITY OF GAS ON INCANDESCENT BURNERS.

At the special meeting of the Institution of Gas Engineers held on September 17 and 18, a very important report from the Gas Investigation Committee was presented. The report is divided into three sections, dealing respectively with (1) ring burners and cookers, (2) upright incandescent mantles, and (3) gas fires, all tested with various grades of gas, and is reproduced *in extenso* in the *Gas World*. The investigations now in progress have a most important bearing on the problem of the quality of gas, and particularly the calorific power, to be aimed at in the future. The section of chief interest to readers of this journal, however, is that dealing with incandescent burners.

It should be noted that the report deals only with burners of the upright type. When corresponding data on inverted burners are available, the conclusions may therefore be subject to modification. But they are instructive as showing the important influence of calorific power on candle-power. In this connection a new basis of reckoning the performance of burners, namely, in terms of "British Thermal Units per candle-hour," is introduced.

The tests were made on a typical upright burner of good modern make, the same mantle being used for as many tests as possible so as to reduce discrepancies due to change of mantles. After each batch of tests a check-test was made to ensure that there was no appreciable deterioration in the mantle used. Eight different qualities of gas were employed, and in each case the number of British Thermal Units supplied to burner per hour varied within wide limits. The eight qualities of gas represented widely different conditions. In some cases a bat's-wing (flat flame) burner would give a satisfactory result, while with other qualities of gas it would give very inferior results or only just "show a light." An examination of the table summarising conditions at maximum efficiency with the respective gases shows that with descending calorific power (552 to 285 net) the candles per cubic foot per hour varied from 5.6 to 14.8, and the British Thermal Units per candle-hour from 33 to 42. The conclusions to be drawn are somewhat complex in view of the number of factors concerned, but there is no doubt that a gas of low calorific power and high inerts gives very inferior results with existing burners in whatever manner they may be used. The effect of adding air varies much according to the nature of the gas, and so, it would appear, does the effect of pressure. Thus with "Coal gas A" a variation in pressure from 15/10 to 35/10 produced a practically uniform maximum candle-power of 53. With "Coal gas "B" the same variation led to a candle-power from 59 to 80; and with the other types of gas used the divergency was in general greater, and the candle-power invariably less. Thus with one quality of coal gas with high inerts the candle-power, with the above range of pressure, varied from 14 to 53. It would appear that with the burner used the best result was obtained with about 525 British Thermal Units gross, and the tests, so far as they have at present proceeded, suggest that a reduction below 500 British Thermal Units is inadvisable for the best efficiency.

The investigation appears to be one of very great consequence to incandescent gas lighting, and the publication of the tests on inverted burners will be awaited with great interest.

## THE ELIMINATION OF FLAT GAS BURNERS.

**The employment of women in Baltimore (U.S.A.) to assist in carrying out the Fuel Administration's request for the substitution of modern burners with a view to saving gas.**

One incidental result of the urgent demand for economy in fuel since the war has been the gradual elimination of the flat flame gas burner in this country —a development which has also been hastened by the fact that in many cases the quality of gas supplied is less suitable for burners of this description than in the past. The stripping of gas for ingredients for munitions work, while having relatively small effect on the performance of incandescent burners, tends to accentuate the inefficiency of the old flat flame burner. Calorific power is thus coming to be regarded as the essential quality in gas from the lighting as well as the heating standpoint.

An interesting incident, which illustrates this tendency, is the movement initiated in Baltimore, U.S.A., by the local supply company, which now employs a considerable number of women to canvass consumers for orders for incandescent burners in place of flat flame ones. According to the *Gas Age*, the campaign has been strikingly successful. The campaign included newspaper insertions, distribution of folders, displays at showrooms, canvas signs, and circular letters, and the enrolment and training of saleswomen. A letter from the Fuel Administrator for Maryland pointing out that " since mantle-burners consume less gas than the old flat flame burners and give more light, the use of incandescent mantles will result in a material saving in gas consumption," was given a prominent place in a Baltimore newspaper, and an appeal to consumers to the same effect was sent out by the company. Originally, a class of forty-two women were collected by an advertisement appeal, the number being subsequently increased to over 100. The training was of a special character. The women had no previous sales experience, and had also to be instructed in installation work, so that they could fit up and maintain burners in first-class order.

The women were organised into squads of five, each under a supervisor or " captain." They were eminently successful from the very start, some selling thirteen lamps during their first day, out of twenty people called upon. The records of the sales suggest that three-fourths of the gas consumers are willing to buy incandescent burners, given the opportunity, and the salary paid to the women salesmen (15 dollars a week plus commission) has been amply justified.

The advantage of using incandescent burners instead of flat flame ones is so obvious that the above results are perhaps hardly surprising. But the incident is interesting as an enterprising adaptation to the present circumstances, the appeal to consumers emphasising the patriotic duty to save gas and at the same time establishing relations which will doubtless prove beneficial to the company in time to come. It is also a striking example of the ability of women to act as an intermediary between the company and the consumer, and they will doubtless find useful occupation in this field after the war as well as in the present emergency.

## ILLUMINATING ENGINEERING SOCIETY (U.S.A.) CONVENTION.

At the Convention of the Illuminating Engineering Society (U.S.A.) a feature was the presentation of a treatise on " War-time Lighting Economics," prepared by the Committee on War Service, and submitted to the United States Fuel Administration as a basis for propaganda on economy in lighting. The treatise was of a popular non-technical nature, and it is suggested that the discussion will be helpful in the present emergency.

Other subjects to be dealt with included the Report of the Committee on Automobile Headlight Specifications, the Lighting of Cantonments, Protective Lighting, and the Effect of Lighting Curtailment upon Accident Hazards.

# THE MINIMUM ENERGY VISIBLE TO THE EYE AS LIGHT.

The question of the minimum amount of light that can be perceived by the eye is of considerable interest scientifically and has also its practical bearing, for example, in relation to the visibility of signal lights or lights on vessels at sea. The matter was referred to in the paper by Professor W. M. Bayliss read before the Illuminating Engineering Society early in the present year,[1] and it may be of interest to summarise some recent work on this subject carried out on the Continent and in the United States.

Some recent determinations are mentioned in a paper by Mons. H. Buisson.[2] One of the earliest determinations, that of Langley, was made for light of wave length 5,500 $\mu\mu$ and was found to be 28 x $10^{-10}$ ergs per second. The value was afterwards determined by Drude, but it is inferred that the value he assumed for the mechanical equivalent of light was incorrect. Reeves found, for the mean of three observers, 17.1 x $10^{-10}$ ergs per second, and for his own eye 19.5 x $10^{-10}$ ergs per second.[3] Mons. Buisson himself by using a special Fabre-Buisson microphotometer, which projects an image of a phosphorescent plate on the eye, has found a lower figure, namely, 12.6 x $10^{-10}$ ergs per second.

It is quite obvious that this constant can only be obtained very approximately, and it is rather surprising that values so far obtained agree as well as they do. The result must depend on definite assumptions regarding the size of the pupil, the colour of the light, the area of the source and its distance from the observer, while the condition of the eye and the personal factor have naturally also great influence.

The experiments of Reeves referred to above, were made with a "star" 1 mm. in diameter viewed at a distance of 3 metres, and thus equivalent to the observation of a distant point-source. This observer has recently extended his observations to the study of two important factors, namely, the size of the illuminated aperture and the period of exposure.[4] He uses the following formula for the determination of least perceptible radiation:

$$\text{Least Perceptible Radiation} = SLM\frac{r^2}{R^2} \text{ ergs per sec.}$$

Here S is the area of the stimulus in square cms.; L the brightness of the stimulus in lamberts; M the mechanical equivalent of light (given by Ives as 1.59 ergs per second per metre candle per square cm., which is equivalent to 0.00159 watt per lumen); r the radius of the pupil; R the distance of the eye from the stimulus.

These experiments on size of stimulus were conducted with areas ranging from a 2 mm. square to a 12 cm. square viewed from a distance of 35 cms. The following results are instructive as showing the very marked effect of size of the aperture:

| Stimulus. | Threshold. M 6. | Energy entering Eye ergs per second. |
|---|---|---|
| 1 mm. star at 3mm. | 0.00720 | $17\times10^{-10}$ |
| ,, ,, 15 mm. | 0.00250 | $24.8\times10^{-10}$ |
| ,, ,, 35 cms. | 0.00024 | $42.1\times10^{-10}$ |
| 2 mm. square at 35 cms. | 0.000028290 | $25.3\times10^{-10}$ |
| 5 mm. ,, ,, | 0.000006625 | 37 ,, |
| 1 cm. ,, ,, | 0.000002413 | 54 ,, |
| 2 cm. ,, ,, | 0.000001023 | 91 ,, |
| 6 cm. ,, ,, | 0.000000258 | 208 ,, |
| 12 cm. ,, ,, | 0.000000175 | 564 ,, |

In the second part of the investigation the author attempted to determine how long a time was required to produce a perceptible sensation. A test spot 3 cm. square was observed at a distance of 3 metres. The intensity was regulated until the observer could just see the star. The star was then covered. Next the star was uncovered again and the time was noted before

[1] ILLUMINATING ENGINEER, April, 1918, p. 104.
[2] *Jour. de Physique*, March-April, 1917, p. 68.
[3] *Astrophysical Journal*, 1917, Vol. XLVI., p. 167.
[4] *Astrophysical Journal*, 1918, Vol. XLVII., p. 141.

the observer again saw the star. For the just perceptible intensity of the stimulus the perception-time varied from 1 to as much as 6 seconds, with an average slightly over two seconds. If a stimulus could not be detected after 4 seconds it was usually not worth while to prolong the exposure further.

Interesting data are also presented showing how the time of exposure is related to the sensibility (reciprocal of threshold). The intensity that could be just detected is tabulated for exposures from 0.002 up to 4 seconds. Over this range of exposure the sensibility rises from 2.76 up to 1,588. The increase is rapid up to 2 seconds, but after this much less so.

## LIGHTING RESTRICTIONS IN IRELAND.

We understand that the Irish Coal Controller has drawn up a Lighting Restrictions Order, which has been sanctioned by the Viceroy, to meet the circumstances resulting from the present coal shortage.

The Order is based on suggestions made by public authorities, manufacturing trades and mercantile and professional bodies. It provides for the abolition of shop-window lighting and lighting outside shops and other premises, and for the closing of shops, warehouses and offices at 5.30 p.m. on four evenings in the week, at 7 o'clock on Fridays, and not later than 9.30 p.m. on Saturdays. Certain exceptions are made in favour of chemists' shops, tobacconists, hairdressers and other establishments. Banks are to close at 2.30 p.m. The quantity of gas or electricity used must not exceed 50 per cent. of that in 1914. Licensed houses are to close between 3.30 p.m. and 6 p.m., and no meals are to be cooked in hotels after 8 p.m. Entertainments and assemblies must terminate by 10 p.m., but no restrictions will be imposed on afternoon performances and meetings during Christmas and New Year holidays.

The amount of gas or electricity used in private houses, hotels, clubs, restaurants, boarding houses, and in offices not working in conjunction with shops, warehouses and factories, must not be more than two-thirds of the quantity used in 1914; in theatres and similar places the consumption of gas or electricity must not exceed 75 per cent. of that used in 1914. Factories will have a preference for gas and electricity for power purposes, but the lighting, except by special permit, must not exceed 80 per cent. of the amount in 1914. Gas and electricity used for public lighting are to be reduced to 50 per cent. of that used in 1914.

Exception has been taken to the proposal to abolish all lighting outside shops, etc., on the ground that this would be a source of danger in the present darkened condition of the streets, and the Dublin Chamber of Commerce express the view that a right of appeal to a representative tribunal should be granted in order to meet cases of hardship that may arise under the restrictions.

## LIGHTING CONDITIONS IN CINEMAS.

The L.C.C. has made further regulations regarding cinemas. No enclosed boxes are permitted. It is prescribed that in no part of a hall is the lighting to be of a lower standard than 0.025 foot-candle, and that wherever possible without detriment to the pictures, and in galleries, etc., lighting of a higher standard must be provided.

## INDUSTRIAL RECONSTRUCTION LECTURES.

A second series of lectures has been arranged by the Industrial Reconstruction Council to take place at the Saddlers' Hall, Cheapside, next year. The first of these will be given by the Minister of Labour on Jan.. 8th at 4.30 p.m., and other lectures by Judge Edward Parry, Mr. E. J. P. Benn, Mr. J. R. Clynes, M.P., Professor A. W. Kirkaldy, and the President of the Board of Education will follow at fortnightly intervals. A full prospectus can be obtained from the Secretary, I.R.C., 2-4, Tudor Street, London, E.C.4.

## TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

### BRITISH COMMERCIAL GAS ASSOCIATION.

SEVENTH ANNUAL MEETING.

At the recent seventh annual meeting of the British Commercial Gas Association, the retiring President (Sir Hallewell Rogers) gave many striking illustrations of the work done by the gas industry in the service of the war. He mentioned, for example, that 14,000 million cubic feet of gas had been used in Birmingham alone for the manufacture of munitions, that the raw material for explosives extracted from Birmingham gas since the outbreak of war was sufficient to fill 25 million 18-pounder high-explosive shells, and that the food production of the country had been helped by several thousand tons of sulphate of ammonia manufactured at the works.

Other topical matters such as the Household Fuel and Lighting Order, were mentioned as illustrating the need for organisation and publicity in the gas industry. The order had had the effect of inducing a large number of consumers to realise, as never before, how dependent they were on gas apparatus. The Association had pursued the wise policy of maintaining their publicity work, and had made full preparations for an " after-the-war " campaign. Everyone administering a gas undertaking with a statutory monopoly of supply should feel that he was under an honourable obligation to increase the use of gas in his area, for the benefit of the public, and he could only accomplish this result by skilful publicity. Publicity methods, showrooms, and exhibitions must be thoroughly up to date and should include business-like, informed, and courteous service on the part of every one of the employees.

Previous to the annual meeting, the outgoing President entertained a representative gathering to meet the President-elect, the Right Hon. Lord Moulton, K.C.B., who likewise emphasised the vast possibilities of the gas industry and the importance of fuller co-operation and research in the years to come.

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The General Electric Co., Ltd., desire to announce that they have completed the purchase of the Erith works, and of the goodwill of the manufacturing business hitherto carried on by Messrs. Fraser and Chalmers, Ltd. Practically the whole of the personnel have transferred their services to the G.E.C., who will carry on the business as a going concern and under the title of " Fraser and Chalmers' Engineering Works. Proprietors: The General Electric Co., Ltd."

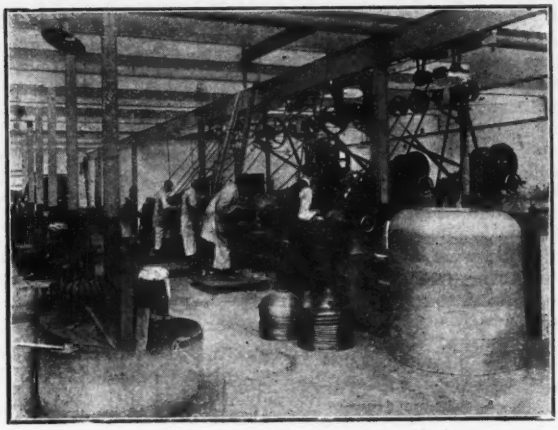
# THE NEW TOTTENHAM WORKS OF BENJAMIN ELECTRIC, LIMITED.

Readers are aware that for many years the manufacture of Benjamin reflectors was carried out at the works of the firm at Rosebery Avenue. The conditions were, however, inconvenient in several respects and considerable adaptability was shown in coping with greatly increased war work at these premises until the present year. Last June, however, the firm removed to a new and modern factory at Tottenham, which we recently had an opportunity of inspecting.

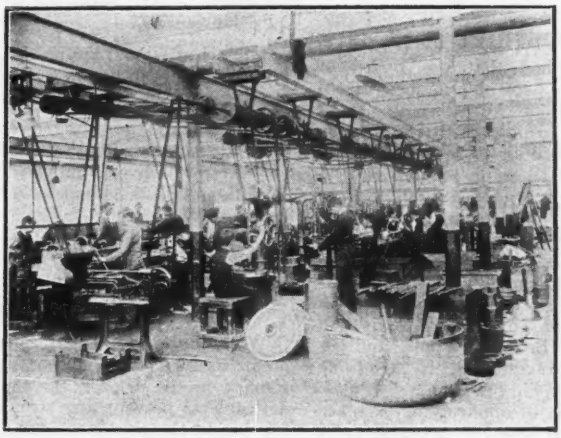
In many respects the new and enlarged works present a great contrast to the old. The design and equipment is on modern lines, all the departments being conveniently assembled on the ground floor, which occupies approximately 20,000 square feet and is provided with a saw-tooth roof giving adequate access to daylight. The offices and various sections of the shop are now conveniently arranged. The main portion of the factory is easily overlooked from the works superintendent's office, and matters are so arranged that material enters at the raw material stores, goes through a cycle of operations in the factory and returns to the store containing finished products. The factory is illuminated electrically on the overhead system, on modern lines, and the light tint of the walls and surroundings is favourable to cleanliness and good diffusion of light. A canteen for workers is provided, and there is a considerable area of adjacent land divided into allotments, which are worked with enthusiasm by the staff of the factory. There is also available ample room for factory extensions.

Although a considerable amount of machinery has been added and the staff enlarged we were informed that the equipment is not yet quite complete. We understand that the special tools needed are entirely made in the machine shop. Besides the large presses for reflector-making, there is a great deal of spinning work done on lathes—a type of operation which one rarely sees in operation in London. In addition to the spinning of reflectors the works are engaged on the manufacture of many special articles in dimensions which must make great demands on the strength and expertness of the spinner. It might almost be said that for the moment these special operations have overshadowed the firm's ordinary production of reflectors and lighting accessories. The latter, however, are in great demand and arrangements have been made to meet requirements fully when the country reverts to peace conditions.

The spinning of large metal surfaces of special contour might, one would imagine, prove useful in the future in the lighting field. The development of gas-filled lamps of increasing candlepower raises interesting speculations as to the ultimate method of lighting large interiors. In place of chandeliers, carrying a large number of relatively small units, one could conceive the use of metal hoods, with a highly reflecting interior, equipped with high candlepower lamps. The weight might prove a limitation, but in the case of very extensive appliances this might be met by the use of aluminium.



SPINNING LATHES FOR REFLECTORS, &C. IN THE FOREGROUND WILL BE SEEN SOME OF THE LARGE ALUMINIUM SPINNINGS ON WHICH THE FIRM IS NOW ENGAGED.



VIEW OF A PORTION OF WORKS, SHOWING MACHINE SHOP.

**Two views of the new modern factory of Benjamin Electric Limited at Tottenham.**

## SPECTACULAR LIGHTING IN TRAFALGAR SQUARE.

Since the outbreak of war there have been few opportunities of seeing what may be termed "spectacular lighting," and the illumination of the exhibits in Trafalgar Square during the recent "Feed the Guns" campaign takes us back to lighting conditions before the war.

The Belgian village was illuminated by a series of 3,000 c.p. gas-filled electric lamps in reflectors, mounted on poles and facing the exhibit. We understand that the lamps and fittings were supplied by the General Electric Co., Ltd.

The effect was rendered the more striking by the contrast with the surrounding darkness due to diminished street lighting. The aim was obviously to conceal the lamps as much as possible and to light up the exhibits, and considering the conditions the effect was good. The position of Trafalgar Square, which was open to view from all four sides, was naturally a somewhat awkward one from the lighting standpoint, as it is difficult in such cases to arrange the lamps in such a manner that they are not seen from some aspect. The problem is much easier when an area is only open to inspection from one direction.

## BRITISH INDUSTRIES FAIR, 1919.

We are informed that the Board of Trade have again been able to obtain from the Port of London Authority the great warehouse in Pennington Street for the British Industries Fair to be held in 1919.

The Fair will open as usual on the last Monday in February, 1919 (February 24th) and will remain open until Friday, March 7th. The Fair will be restricted to the same trades which have participated in previous fairs, namely, Glass and Pottery; Paper, Printing and Stationery; Fancy Goods and Toys. Invitations will be issued by the Board of Trade, and admittance wil be restricted to *bona-fide* buyers interested in the above trades. Over 2,000 forms of application for space have already been issued to manufacturers in the trades concerned and it is expected that the number of firms anxious to take part will be in advance of last year when orders to the value of over 1½ million were placed. Full particulars may be obtained from the Director, British Industries Fair, Board of Trade, 10, Basinghall Street, London, E.C.

## THE ELECTRICITY (RESTRICTION OF NEW SUPPLY) ORDER, 1918.

(Dated 8th November, 1918.)

The above Order issued by the Ministry of Munitions directs that:

No person shall on or after the date hereof, except under and in accordance with the terms of a permit issued under authority of the Ministry of Munitions:

(*a*) Connect or cause to be connected to any source or means of supply of electricity any place or any building, premises, or plant, or any part thereof not so connected at the date hereof, or

(*b*) Supply or cause to be supplied any electricity to any place or any building, premises, or plant, or any part thereof not supplied with electricity at the date hereof, or

(*c*) Use or cause to be used any electricity in or at any such place, building, or premises, or for the purpose of any such plant as hereinbefore mentioned.

In cases where the previous assent of the Local Fuel Overseer has been obtained for the fitting, equipment, and supply of electricity under the Household Fuel and Lighting Order, 1918, no permit is required.

The permission required is supplementary to and not in lieu of the usual Priority Certificates and permit reference number.

All applications with reference to this Order are to be directed to the Director of Electric Power Supply, Ministry of Munitions, 8, Northumberland Avenue, London, W.C. 2.

## SCREENING STRAY LIGHT FROM FLOOD-LIGHTING PROJECTORS.

When lighting the exteriors of fenced areas for protective purposes, as is customary in the United States, it is often desirable to prevent any stray light entering inside the protected area, so that the watchman can be himself in darkness and survey more easily the lighted area outside. The National X-Ray Reflector Co., of Chicago have accordingly produced a special shield for use with flood-light projectors which eliminates such stray light without impairing the main illuminating beam.

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### NATIONAL PHYSICAL LABORATORY ANNUAL REPORT (1917-1918)

With further reference to the remarks made on the subject of measuring total flux of light and mean spherical candle-power in a recent issue of this journal,* it is of interest to note, in the Annual Report (1917-1918) of the National Physical Laboratory, an account of some work done on gas-filled lamps. A cubical integrating photometer has been adapted for this work, employed with the necessary precautions as regards the similarity of the distribution of light of the standard used in the calibration. Existing conditions have so far prevented the installation of a spherical photometer for the purpose, and much remains to be done in perfecting methods of this character when normal conditions return. The work is generally carried out by using a suitable light filter in conjunction with a standard vacuum lamp running at normal temperature.

Other investigations of interest recorded in the Report include the testing of Goliath lamp sockets. Large gas-filled lamps cause considerable heating of lamp sockets. At the request of the Engineering Standards Committee, measurements were made of the rise in temperature of ventilated and unventilated sockets and of the leading-in cables when used in lanterns of the open and enclosed types. It was found that such cables are liable to be subjected to a temperature rise of about 140 degrees C., and that little improvement resulted from the use of existing arrangements for socket ventilation.

As regards tests of luminous compounds, it is of interest to note that beside routine work an enquiry has been made into the use of self-luminous graticules for gun-sights and several graticules have been developed in the laboratory.

* Aug., 1918, p. 186.

### SIR GEORGE LIVESEY'S WORK.

In a recent issue of the *Co-partnership Journal* it is recalled that just ten years have elapsed since the death of Sir George Livesey on October 4, 1908. Events since the outbreak of war have strikingly justified his pioneering work in the field of co-partnership.

It is pointed out that the Co-partnership Committee, devised over a quarter of a century before the issue of the Whitley Report, contained the essence of modern ideas regarding opportunity being afforded for frank discussion and joint action between management and employees. Co-partnership has been faced with a severe test in the economic upheaval arising from the war, and the experience of the South Metropolitan Gas Company has fully proved its vitality in the years following the loss of its great originator.

## REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

*Institution of Gas Engineers Transactions* (1917).

The Transactions of the Institution of Gas Engineers for 1917 contain the inaugural address of the President for the year, Mr. A. E. Broadberry, the usual annual report, and much information in the form of reports of committees on refractories, gas meter research, etc. Special reference is made to the question of naphthalene stoppages. There is also an account of a visit to the Tottenham Gas Works, and a series of abstracts of papers published in various technical journals. The volume is concluded by memoirs of gas engineers who passed away during the year.

*"Defective Oxy-acetylene Welds." By Capt. D. Richardson, R.A.F., and "The Impurities in Acetylene," by Charles Bingham (6d. each; published by the British Acetylene and Welding Association, London).*

No. 1 of these two little booklets is a reprint of the paper read by Capt. Richardson before the British Acetylene and Welding Association in March of the present year. No. 2 is a paper read by Mr. Chas. Bingham on June 27.

The Association is to be congratulated on the step of issuing these papers in booklet form. Both contain a considerable amount of very practical information, and should be especially appreciated at the present time when welding plays such an important part in repair work, both on land and sea.

*"Journal of the Society of Glass Technology" (Sept., 1918).*

This issue of the Journal of the Society of Glass Technology, like its predecessors, contains much useful information. The papers deal with various technical problems such as "The Firing of Glass Pots," "Pot Failure," "Resistant Properties of Foreign Chemical Glassware," etc., and there is an interesting report presented on problems that require attention. We note that the latter includes the production of neutral tinted optical glasses and the production of a soft, easily-workable glass for lamp-working and for electric-lighting bulbs. The volume is concluded by the usual series of abstracts of articles in the British and foreign technical press.

*"The Investigation of Pulverised Fuel Systems in America."*

We are informed that Mr. Leonard C. Harvey has returned from the United States after having carried out for the Director of Fuel Research a full investigation into the progress made in recent years in the application of pulverised coal for metallurgical and general purposes and for steam raising in land and marine boilers and in locomotives on railways.

The information and data collected by Mr. Harvey, together with descriptions of numerous installations, will be issued by the Department of Scientific and Industrial Research as a Government publication at an early date.

*"A Simplified Method of Tracing Rays through an Optical System." By Prof. L. Silberstein (Longmans, Green and Co., London, 1918. 5s. net). Pp. 37.*

In this work Dr. L. Silberstein, Professor at the University of Rome, explains a new vectorial system of treating optical problems, which is particularly adapted to "ray-tracing." The first chapter explains the application of the system to the fundamental laws of reflection and refraction, and the author then proceeds to consider in turn plane and spherical surfaces, mirrors and reflectors. The book should be of considerable interest to students of optics.

## Obituary.

### ALFRED SHERWOOD ESSLEMONT, O.B.E.

It is with great regret that we record the death of Mr. A. S. Esslemont, Controller of the Optical Munitions and Glassware Supply, and British Potash Departments (M.O.M.), on September 14.

The work undertaken by Mr. Esslemont since the outbreak of war has been of a high technical and exacting character, and he was generally recognised to have shown great skill and organising ability in grappling with the many novel and difficult problems involved. Apart from its direct relation to the needs of the war, much of his work was of permanent value to the glass industry and he was a leading spirit in the formation of the Society of Glass Technology, of which he was elected a Vice-President. His death at the early age of 41 years is a great loss to the industry.

10

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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# EDITORIAL.

## The Lighting of London: Past, Present and Future.

With the cessation of hostilities and the relaxation of the lighting restrictions, Londoners have naturally exulted in the brightening of the streets and are looking forward to the restoration of the conditions associated with the normal peaceful experience before the storm burst in August, 1914. Immediately after the conclusion of the armistice the authorities sanctioned the removal of restrictions as affecting the screening of public lamps, subject to the continued diminution of 50 per cent. of lighting in the interests of fuel-saving. Accordingly the masking of the lamps is being removed as quickly as possible, and already our streets are beginning to take on their familiar pre-war appearance.

We need scarcely say that we welcome this provision of a higher illumination. Experience during the past years has impressed on everyone the vital importance of adequate street lighting in the interests of safety. There is no reason to think that the amount of illumination provided in streets before the war was excessive; indeed, economical considerations have so far set the limit in this respect, and we have not yet reached the amount of illumination which would be beneficial both for safety and convenience of traffic. At the same time we think it would be hasty, in the jubilation at this partial restoration of normal lighting,

to assume that a return to pre-war practice is all that is required. The restrictions since the war—irksome, but cheerfully endured—have not been without their useful lessons. Our future course should be not merely to imitate but to improve upon methods of the past.

The early measures adopted for the screening of street lamps and the diminution of public lighting were admittedly defective, and, so far as one can judge from the data available, were a contributory cause of the marked increase in street accidents that made itself evident after the outbreak of the war. We have previously pointed out that the complete relation between lighting and street accidents could only be established by the careful scrutiny of much fuller data, and we still hold that such a survey should be one of the measures of reconstruction in regard to public lighting. But experience has established the drawbacks of certain conditions which the authorities, acting under expert advice, were able largely to eliminate by their subsequent more satisfactory methods.

Among such defects may be mentioned glare from unscreened powerful lamps (either used for public lighting, or outside private premises), which are so placed as to dazzle the eyes of drivers and pedestrians, and thus constitute a danger to the safety of traffic; violent transitions from brightness to darkness in the roadway; and similar severe contrasts, either in passing from a main thoroughfare to a side street or in traversing from one district to another. Military considerations endorsed the principle, already becoming recognised before the war, of essentially uniform lighting throughout the Greater London area. There are also a variety of special measures arising from the needs of traffic, which have been initiated at meetings of the London "Safety First" Council, in the course of the very valuable work which this body has done in the interests of street safety.

The principles and methods referred to are of general application throughout the Greater London area, and the principles to be followed in avoiding glare and undue contrasts are of uniform application. We think, therefore, that the time is ripe for a full discussion of the essential principles of street lighting, bearing in mind the lessons of the war, and the new devices which have been withheld but may be expected to be introduced in the near future. We are glad to note that the Illuminating Engineering Society contemplates arranging such a discussion early in the session.

Finally, we think that there is one specially important lesson from the war which should not be overlooked—the provision of machinery whereby uniformity of practice in London can be achieved through the co-operation of the various local authorities and other bodies interested. Military considerations have made such co-operation a necessity since the outbreak of war. Can we not achieve concerted action in improving the lighting of London as we have done in diminishing it? We hope that one of the benefits to be derived from war experience will be the formation of some central body, representative of the local authorities, the Illuminating Engineering Society, the London "Safety First" Council, and the Government Departments concerned, whereby recommendations for the guidance of all sections of London can be prepared.

### Economy in Lighting and Fixture Design.

We recently drew attention to the interesting step taken by the United States Fuel Administration, after consultation with the leading manufacturers of electric incandescent lamps, to encourage the manufacture of tungsten filament lamps and arrange for the gradual discontinuance of those with carbon filaments.* In the field of gas-lighting there has been a similar movement towards the elimination of flat-flame burners, and energetic action has been taken in this direction.

We observe that the Administration has now addressed a communication to makers of electric fittings, pointing out that lamp manufacturers have been called upon to abandon the manufacture of standard carbon filament lamps of specified types, that central stations have been asked to abandon renewals both of carbon filament and metallised filament lamps, and that the design of fixtures should be modified accordingly. It is added: "The United States Fuel Administration requests your co-operation in so designing fixtures as to further the use of the most efficient types of lamps, particularly the employment of single large lamps rather than a number of smaller lamps of lower efficiency."

The departure in regard to lamps was recognised as a progressive and enterprising step, of permanent benefit to the lighting industry as well as of immediate utility as a measure promoting fuel-saving. The logical application of the same principle to the design of fittings will also be beneficial, provided that it is carried out under proper supervision. But *The Electrical Review and Western Electrician* remarks that the opportunity should be taken to bring about an improvement in the design of fittings generally. Many existing fittings for carbon filament lamps are of poor design from the illuminating engineering standpoint, and these faults should not be perpetuated in the new fittings. This is the more necessary because, in using tungsten vacuum and gas-filled lamps, we have to deal with a higher brilliancy. Proper methods of shading are therefore essential to visual comfort. The idea is still too prevalent that the use of a shade or reflector, because it necessarily involves some loss of light, is prejudicial to efficiency, and we also see in this country cases in which people have unwisely abandoned the shades used with lamps thinking that by so doing they save light and economise in fuel.

It is therefore necessary to impress on fixture manufacturers that good distribution of light and freedom from glare are quite as important as high efficiency in the lamp itself. Moreover, the neglect of these principles results in a displeasing effect from the æsthetic standpoint. Elimination of glare is essential to visual comfort, and, speaking generally, a fixture that causes discomfort to the eye cannot be considered an artistic object.

It is suggested that a committee of the Illuminating Engineering Society in the United States should be formed to co-operate with the Fuel Administration and with the fixture manufacturers in giving general guidance on the important principles to be followed in re-designing existing appliances. Such co-operation would doubtless be helpful, and would furnish an additional instance of the advantages of the proper use of technical information and advice by the State.

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* ILLUMINATING ENGINEER, August, 1918, p. 186.

### The Æsthetic Aspects of Illumination.

Since the outbreak of war in 1914 our attention has been necessarily devoted almost entirely to the strictly utilitarian aspects of lighting. The restrictions and economies enforced by the war alone sufficed to keep the artistic and decorative sides of illuminating engineering in the background, and it is probable that we shall not be entirely free from this check for many years to come.

Yet the cessation of hostilities and the restoration of a measure of normal street-lighting conditions furnish us with a reminder that a new era is on the way. In the days to come there will be many new lighting schemes to be initiated—many developments that have been held over since the war. And in many of these schemes æsthetic aspects of lighting will quite properly play a part. While we must still be on our guard against waste, we must beware of the fallacy that an ugly thing is necessarily efficient. Many of the artistic faults in lighting are also offences against the comfort of the eye, or are due to false measures of economy.

We are reminded of these aspects of lighting by the commencement of a series of articles on " Linking Science and Art in Lighting," contributed by Mr. M. Luckiesh to the *Electrical Review and Western Electrician*. Mr. Luckiesh estimates that artistic considerations play a part in quite one-half of the whole lighting field. They enter into domestic lighting, the lighting of large halls, picture galleries, museums, etc., and they should receive consideration in street-lighting, though it must be confessed that relatively little has been done in this direction as yet. There are many experts concerned in the lighting of an interior—the architect, builder, contractor, fixture dealer, central-station engineer, and decorator, to name only a few, all of whom must be brought together in order to evolve a common understanding of lighting. In many cases installations are made without artistic questions receiving a proper measure of attention. In other cases, the problem is regarded in a one-sided manner, architects and fixture designers, for example, not infrequently bestow most consideration on the appearance of a fixture seen by daylight, and relatively little on its appearance when lighted up. A very common fault in buildings, which illustrates false economy, is the neglect to provide a sufficiency of outlets and switching appliances. Consumers who have been induced to " economise " in this way, pay the penalty in these days when lack of proper control of lights makes true economy a difficult problem. It also seriously cramps the artistic possibilities of lighting; the absence of an adequate number of spare outlets means that the system lacks adaptability, that there are inadequate facilities for variety of treatment and alternative methods.

While therefore we recognise the many urgent practical problems in lighting which command our first attention in these times, we think that the artistic side of illumination deserves to be rescued from entire neglect, and that the cultivation of lighting as an art as well as a science should not be overlooked. For this reason we hope that in such schemes at the British Institute of Industrial Art, to which we referred in our last issue, the design of pleasing and graceful lighting fittings, and the possibilities of using light as a decorative medium, will receive fitting consideration.

LEON GASTER.

# LIGHTING INTENSITIES IN RELATION TO PRODUCTIVE POWER.*

By W. A. DURGIN.

The selection of the illumination values necessary for maximum production in various industrial processes is a matter of vital importance. During the period of the war the greatest need has been to speed up, in every possible way, the productive power of munitions works of all kinds. In the coming period of reconstruction every nation will be forced to strain every effort to produce useful things, in order to make good the wastage of the war.

In this article Mr. W. A. Durgin, who is lighting assistant to the vice-president of the Commonwealth Edison Co. in Chicago, shows, by some practical examples, how output can be accelerated by an improvement in illumination. The chief problem is to determine the limit beyond which an increase in illumination has little or no influence on production. The experiments described suggest that this limit is much higher than is commonly supposed. Hitherto we have had available few definite data on this important problem. Although the requirements of industrial lighting have been carefully studied by the Departmental (Home Office) Committee on Lighting in Factories and Workshops in this country, and various lighting codes have been adopted for factories by various States in America, all that has been attempted is to specify broadly degrees of illumination which are considered "adequate" for various grades of work. These specifications are based on the considered views of lighting engineers, but they are to be regarded rather as the essential minimum than as the useful limit of illumination. The latter appears to require determination.

It would obviously require a most exhaustive survey of different industries to settle this problem. Companies such as the Commonwealth Edison Co. of Chicago, who are responsible for the installation and maintenance of lighting in a great variety of factories, are obviously in a specially favourable position to make such a survey, and they have recently embarked on a comprehensive investigation, which is intended to cover every industrial plant using central-station service in Chicago, which has a connected load of 100 kw. or more. At present there are 663 such plants, of which 93 have so far been surveyed. The 93 plants total 17,400 employees, cover a floor area of 96 acres, and aggregate a lighting load of 1,420 kw. The results of the survey show that in these plants there is a mean of 1½ foot-candles provided (with variations from 0.01 to 10 foot-candles), and an average consumption of 0.33 watt per square foot, and 80 watts per employee. For these same plants the code of the Illuminating Enginering Society in the United States (on which the codes adopted in the legislation of the various States are based) would provide an average illumination of 5.5 foot-candles, *i.e.*, 3.66 times the present average value. The intensity, according to the various kinds of work undertaken, should vary from 2 to 12 foot-candles, the average consumption should be one watt per square foot, and 240 watts per employee, or three times the present consumption. Thus, in terms of the amount of illumination provided, the conditions are not adequate, and when the unsatisfactory condition of shading, giving rise to glare, is also considered, the departure from the ideal becomes still more marked. In this connection Mr. Durgin presents some illustrations of typical reflectors and fittings which were observed. These are of the shallow, unsatisfactory type, in common use some years ago but now considered quite out of date. Such reflectors do not screen the lamp from the eye and embrace such a small proportion of

* Abstract of an article in *The Electrical Review and Western Electrician.*

the total flux of light that only a very small part of the available light is concentrated in a useful direction.

In order to substantiate the view that such lighting conditions are inefficient and uneconomical, it was arranged that lighting surveyors approaching factories with a view to making improvements in lighting should also try to provide for a statistical investigation showing the relationship of improved lighting to output. The suggested programme was to run for four months, taking full particulars of the conditions of output, the first month being run with the existing lighting; the second month with proper equipment to give 50 per cent. higher intensity than the maximum recommended by the code; the third month at the lower code level, which is commonly considered sufficient for ordinary practice; and the fourth again at the higher or production-intensity level. For the success of the tests the record of output must be exactly kept and a fair percentage of the work must be done in hours of darkness. The chief difficulties are two, namely:

(1) To find plants with adequate production-record systems, and (2) to induce the owners of the plant to return to the lower level of intensity at the end of the second month of the run after the advantage of the good lighting has been experienced.

So far tests of this kind have been applied to eleven plants, and from two of these reliable data have already been obtained. In one case the test was run in a machine shop producing soft metal bearings, operations ranging from rough to fine. Only two months of the programme were run, but in the month during which the intensity was maintained at the 12-foot-candles level, production in the several operations was increased by from 8 to 27 per cent. over that prevailing in the previous month when an average intensity of 4 foot-candles was provided. The superintendent was so impressed by the value of the higher intensity that he had the system extended to the other floors of the building.

In the second test the programme could not be followed so carefully, the comparison being between bare lamps on drop cords and a properly designed reflector-cap installation. But the new equipment gave about 25 times the illumination previously used and showed an increase in production of from 30 per cent. to 100 per cent. in several operations in a large pulley machine shop. In the other nine tests in plants it was not found practicable to run tests, but in every case the superintendents and owners were convinced of the truth of the statement that the average effect will be at least 15 per cent. increase in production at an increased cost of lighting of not more than 5 per cent. of the pay-roll. Further tests on factories of widely different character are now being conducted, in each case the company bearing the cost of the equipment on the understanding that if the owner is convinced of its value he will purchase after the test at the regular prices.

During the period of the war efforts have been made to standardise equipment with a view to rapid installation. To get results quickly it is impracticable to secure absolutely the best equipment for each installation, and it was necessary to adopt three main types of equipment:

(1) Gas-filled lamps with steel reflectors and eye-shields for 200, 300, and 500 watt sizes.
(2) Gas-filled lamps with deep bowl reflectors for extreme mounting heights.
(3) Vacuum lamps and deep bowl reflectors for certain drop-cord applications.

Effort has been concentrated mainly on the first type, the 300-watt unit being mainly employed. A feature of these units is the eye-shield, a shallow diffusing ring attached to the reflector and surrounding the light source so as to keep it out of range of vision. It is of vital importance that the eye-shield should be sealed in place and incapable of removal except by the foreman or some authorised employee,

For the ordinary workman believes only in one part of the code. He wants more light but he knows little of the effect of excessive contrasts in brightness, and if left to himself will remove the shield as a useless obstruction. Accordingly recent installations of these units are equipped with sealing wires. The 300-watt unit, which is mainly encouraged, has an efficiency of about 84 per cent. and a maximum brightness of 7,500 millilamberts on the interior of the diffusing ring, and is well adapted to use on present outlets. The maximum candle-power is at 50° and it is quite practicable to produce reasonably uniform lighting with spacings of 14 to 16 feet at mounting heights of 10 to 16 feet. When 12 to 18 feet mounting heights are practicable spacings up to 20 feet can be employed with the 500-watt unit, which has an efficiency of 77 per cent. and a maximum brightness of 2,300 millilamberts.

Of special importance during the war has been the ease with which such installations can be maintained. With the older types of shallow reflectors now being discarded the effect of dust deposits and handling by workers with greasy fingers was most detrimental, and many such installations have been found where the utilisation efficiency was not more than 25 per cent.

For the 92 factories under consideration the total consumption is 4,826,000 kw.-hours of which 203,000, or roughly 4 per cent., are used for lighting. To attain the high production level this would have to be raised to 640,000 kw.-hours, which would mean a 9 per cent. increase in fuel consumption. But if, as has been shown, this increase would lead to an average gain in output of 15 per cent., it is contended that the relatively small extra consumption in fuel would be well worth while. The determination of the amount of illumination giving the maximum productive effect in various industrial operations is clearly a most fruitful and important investigation.

## THE RENOVATION OF DISCOLOURED ARC LAMP GLOBES.

It is well known that arc lamp globes containing an appreciable amount of manganese may become discoloured under the influence of light, a purple coloration eventually resulting. It will be recalled that the fact of the purple coloration being eliminated by the application of heat was pointed out by Mr. M. Luckiesh in an article on this subject in the *General Electric Review*, which was abstracted in our journal in August, 1917. In an article in the *Electrical World* Mr. A. Herz describes how globes can be conveniently restored to their former transparency in practice by heating in ovens, the temperature being very exactly adjusted. For the removal of this discoloration no scouring method will answer, as the colour penetrates more or less deeply into the interior of the globe according to the time during which it has been exposed to light; the action of heat in this respect seems to be analogous to the removal, at a high temperature, of the discoloration of glass, some varieties of glass following exposure to the emanations of radium.

The globes to which the author refers were used with magnetite lamps which, in addition to the deep-seated coloration, are apt to produce superficial staining due to iron oxide. This is carefully removed by cleaning with muriatic acid before the globes are inserted in the oven. The whole process takes about 24 hours and the cost of gas used to heat the oven is small. It is calculated the entire cost of renovation does not exceed 35 cents, whereas the globes at the present time cost about 2 dollars. The treated globes, so far as present experience goes, appear to remain sufficiently clear for 75 per cent. of the time necessary to discolour entirely new globes. In view of the shortage of globes that has prevailed since the war, and the rise in price, measures that prolong their life deserve to be widely known.

## THE DEVELOPMENT OF ELECTRIC INCANDESCENT LAMPS.

In a review of the present position of electric incandescent lamps, which has been appearing in the *Revista Tecnica d'Electricita*,* the question of the correct measurement and definition of candle-power is discussed, and attention is drawn to the movement towards specification in lumens, both in this country and in the United States. It is recognised that the total flux of light produced, both by lamps and by units comprising suitable globes and reflectors, is an essential quantity, and that in many cases the introduction of rating in lumens would lead to the simplification of many existing formulæ.

The following table, summarising the advances made in the efficiency of electric incandescent lamps, is of interest:—

| Type of Filament. | Date. | E.D. Volts. | C.P. | Watts per C.P. |
|---|---|---|---|---|
| Carbon | 1880 | 100 | 10-50 | 5.0 |
| " | 1889 | 200 | — | |
| Nernst | 1898 | 110 | 65 | 1.5 |
| " | 1903 | 250 | 150 | 1.5 |
| Osmium | 1902 | 65 | 35 | 1.7 |
| Tantalum | 1905 | 110 | — | 1.9 |
| Tungsten | 1906 | 100 | 8-500 | 1.25 |
| " | 1908 | 100 | 6-300 | 1.25 |
| " | 1909 | 220 | 8-1000 | 1.25 |
| Tungsten (drawn wire) | 1910 | 100-250 | 20-1000 | 1.25 |
| Gas-filled | 1913 | 50-250 | 30-75000 | 0.65 |
| " | -1915 | 25-250 | 30-3000 | 0.65 |
| Tungsten (arc-incandescent) | 1915 | 50 | 100 | 0.65 |

## THE EDUCATION OF THE OPTICIAN.

In an article in the *Zeitschrift für Instrumentenkunde*, Dr. O. Henker recently gave an account of the chief objects of the Jena schools of applied optics. The qualifications of the optician are discussed in detail, and it is pointed out that his chief function is not merely to be proficient in the mechanical processes of his trade, but to be qualified to act as a medium between the public and the optical industry. A synopsis of the course of education, which include a knowledge of spectacles, optical instruments, etc.

* August 25, 1918.

## COLOURING GLASS BY ULTRA-VIOLET LIGHT.

It has long been known that certain varieties of clear glass become coloured after prolonged exposure to light, especially the ultra-violet rays, glass containing manganese being a notable example of this effect. According to some experiments recently described by Mr. H. Rosenthal, reported in the *Journal* of the Society of Glass Technology, special coloration can be deliberately produced by subjecting appropriate glasses to the influence of ultra-violet rays or X-ray bombardment. The ordinary quartz tube mercury vapour lamp and the Coolidge X-ray tube are mentioned as suitable sources.

The method is claimed to open up a new art in the colouring of glasses and analogous substances such as porcelain, quartz and some of the precious and semi-precious stones. White optical glass which has been subjected to such treatment has the same characteristics as when the original clear glass has been exposed to sunlight for many years. The coloration shades off as one reaches the parts of a glass object most remote from the rays. Apparently no physical change, other than that of colour, could be detected in the glasses subjected to the process. The author diagnoses the effect as chemical rather than physical.

## THE PHOSPHORESCENCE OF CALCITE.

In the *Physical Review* Messrs. E. Nichols, H. L. Howes and D. T. Wilbur describe some interesting experiments on the phosphorescence of certain samples of calcite, excited both by exposure to light and by kathodic bombardment. The former only persists for 0.4 seconds, and is red in colour; the latter, also red, is measurable after 300 seconds. The phosphorescence is affected by rising temperature, but the rate of decay is apparently not affected by the application of red or infra-red rays.

# LUMINOUS SIGNS AS A MEANS OF IMPARTING INFORMATION.

By An Engineering Correspondent.

Among the many problems of reconstruction in regard to lighting, great interest attaches to the fuller use of luminous signs as a means of imparting information. Recently lighting restrictions have practically eliminated this practice so far as outdoor lighting is concerned, but in the near future it should be resumed.

In former times, when but a small fraction of the people could read and write, distinctive signs were the usual method of conveying knowledge. The old inn signs are a survival of this practice, likewise the barber's pole. When the development of artificial lighting permitted the extension of this practice by night, people had recourse to lamps; for example, the red lamp outside the doctor's, and the series of coloured bottles, conveniently illuminated by the lights in the shop, at the chemist's. The tendency to use agreed devices for danger-signals is perhaps a survival of the sign-period, although as regards notice to traffic there is also the factor that a sign can be more quickly seen than a notice in words.

Nevertheless, it seems likely, in view of the spread of popular education and the improvement in facilities for lighting, that illuminated notices will tend to replace signs. They can convey more detailed information, are more easily understood by strangers and foreigners, and have the advantage that they can be made equally effective by day and night. There is no reason why, in the future, all names of shops should not be illuminated, and likewise to a very great extent notices of professional men, doctors, solicitors, etc., while even street names and addresses may eventually be illuminated as a matter of common practice. Anyone who fails to appreciate this point will soon alter his opinion if he takes a walk down Bouverie Street in search of the offices of some particular journal. In the night time the problem is a most difficult one to a stranger, and the few cases in which an illuminated indication of the office of a paper exist show up in striking contrast the obscurity reigning round neighbouring offices. We have already seen at railway stations what effective use can be made of the illuminated signs, and in theatrical notices and for purposes of advertisement the illuminated sign before the war was becoming more and more usual.

From the illuminating engineering standpoint the spread of this practice should be encouraged, provided that glare is avoided, and that the signs have a suitable mild luminosty enabling them to be easily read, but not offending the eye. It should be practicable to set a limit to the intrinsic brilliancy of such signs in the interests of public convenience, and possibly we may also be able to arrange for standard procedure with regard to notices of an official character, so that these can be readily distinguished from advertisements.

In the case of buildings provided with ordinary lighting facilities, the use of luminous devices is an easy matter. For example, the illuminated name should be an integral part of shop-lighting, and in private houses and offices it should often be quite practicable to arrange that the light in the hall or vestibule illuminates a translucent notice clearly visible from outside. The convenience to strangers of thus indicating the nature and number of every building in a street is obvious. In the City it would often save much time in locating an office, while there is also no objection to applying the method to

important or interesting public buildings, such as Government Departments, or even buildings of historic interest. In the latter case the design of the signs would naturally require care, but there is no reason why artificial light should not be applied in this way without incongruity, and in keeping with the traditions of the building.

The use of artificially lighted names to streets is naturally a somewhat more difficult matter, as it involves running special wires at the public expense; but in the case of important thoroughfares it is at least worth attention. While the ideal solution would be a translucent illuminated box-sign, the practice of fixing street names to lamp-posts is a method of easy present application. It should be the practice to locate enamelled signs in positions and at levels where they receive light from street lamps, while lanterns at the ends of streets might carry a strip on which the name of the street is clearly indicated. In the case of side streets and streets in the suburbs the problem may possibly be solved eventually by the use of a cheap form of self-luminous paint, which would give the relatively feeble luminosity necessary to enable the name to be seen in the comparatively dark surroundings.

The more general use of such methods would be an immense gain from the standpoint of public convenience. But its utility does not stop here. One of the greatest difficulties in street lighting arises from the fact that it is at present provided by relatively few lamps, spaced at considerable intervals, and therefore giving but a feeble illumination in many parts of the street. The contrasts in the street as a whole, even supposing that the illumination on the roadway and pavement is fairly uniform, are necessarily great, and as the illuminating sources are small in area and little assistance is derived from reflection from the surface of buildings, one observes sharp shadows. An object is thus illuminated from a few directions, not from all points of the compass as in a well-lighted interior, and is therefore often most imperfectly distinguished. We can judge of its outline, but not of its depth and shape.

Everyone recognises the great aid afforded by light streaming into the roadway from shops, provided that proper methods of screening are adopted and the light is well diffused. Similarly the general use of illuminated signs to give information of any kind would provide a large number of small sources of mild luminosity, distributed throughout the street, and do a great deal to relieve the severe contrasts characteristic of most street lighting.

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## RESPONSIBILITY FOR UNLIGHTED STREET STANDARDS.

An interesting case, bearing on the responsibility of public lighting authorities, was recently reported in the *Gas Journal*. The action was brought by a taxi-cab proprietor against the Westminster City Council and the Charing Cross, West End and City Electricity Co., Ltd., for damage to a cab arising through collision with an unlighted street-refuge near Trafalgar Square. The various questions submitted to the jury included the enquiries whether the accident was really due to the inevitable causes arising from the general defective street-lighting, or the result of negligence with regard to this particular lamp. It was also argued that the defendants were not under an obligation to provide light for street-refuges, but that in any case they had provided a lamp and could not be held responsible for the fact of its being extinguished on the night when the accident occurred. Their difficulties had been added to by the series of Orders restricting public lighting, and by the fact that the mechanism of the arc lamp at the refuge did not work satisfactorily owing to the reduction of electric power. Judgment was given against the defendants. They appealed to the Court of Appeal, who, however, upheld the original verdict.

# A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

**Some Notes on the Report of Progress of the American Illuminating Engineering Society.**

The usual report of the Committee on Progress of the Illuminating Engineering Society in the United States, presented at the recent convention, evidently contains much interesting information, although we have not received the full draft of the report to date. A summary of its contents was, however, recently given in the *American Gas Engineering Journal*, from which the following notes are taken. Much of this deals with special developments arising from the war, special reference being made to war-time lighting economies, but there are also instances of technical progress.

### LIGHTING RESTRICTIONS IN WAR TIME.

In the United States, as in this country, there has been a series of Orders restricting public and private lighting, and a survey is made of these, together with some notes on conditions in Europe. The first action taken by the United States Government, on November 9, 1916, was the restriction of sign-lighting between 7.45 p.m. and 11 p.m. Subsequently a plan for "lightless nights" was put into effect, and, besides providing for the extinction of all but strictly necessary public lamps on Thursdays and Sundays, specified certain restrictive measures in regard to indoor lighting. In January, 1917, a still more drastic order, making the rules apply to every night except Saturdays, was introduced in New York, but subsequently these were replaced by a new Order which came into effect in July. Measures introduced in various States had reference mainly to sign-lighting, but it appears to be recognised that, apart from their utility in impressing the mind of the public, they were only instrumental in saving a relatively small amount of coal. Thus in Boston it was stated that 3,300 illuminated signs only consumed electricity equivalent to 0.7 per cent. of the supply company's coal. In regard to street-lighting the advantages of curtailment were regarded as doubtful, as complaints on the ground of insufficient lighting have been made by various cities. The whole position has been discussed in several papers before the American Illuminating Engineering Society.

### PROTECTIVE AND FLOOD LIGHTING.

On the other hand, great attention has been paid to "protective lighting," *i.e.*, the use of special flood-lighting near important spots to prevent the entrance of unauthorised persons. Among instances of such lighting are mentioned the lighting of the oil-well region in Oklahoma, one area so lighted being 14 miles long by 3-4 miles wide. An interesting development has been the application of oil-lighting on this basis; for example, 14-in. silvered reflectors in front of incandescent gas-mantles have been used to protect an important Western dam. Power houses have taken special measures; thus one house supplying power to a large lead and zinc mining district leaves the building dark (to external view), but brilliantly illuminates all the avenues of approach. The United States War Department has issued a pamphlet on "Protective Lighting," emphasising the value of the system for important public works and property vital to the prosecution of the war.

In other cases special lighting has been applied to enable important work to be carried on at night. Thus threshing has been carried on by artificial light, and the use of both electric and gas lighting to illuminate outdoor recreation grounds is referred to. An important feature (which naturally could not be reproduced in European cities in the war zone) was the establishment of lighthouses with upward

beams at important centres, intended to mark out the courses for aircraft.

Camouflage problems are also the subject of reference. It is remarked that systems based on colour combinations have not been very successful; in some cases their effect can be defeated by the use of tinted binoculars, whereby the colour contrast is largely eliminated. In particular, it is pointed out, that a really successful system of camouflage must deceive not only the eye but also the camera.

### Gas-Lighting, &c.

In the field of gas-lighting attention is drawn to the successful amalgamation of the two largest societies concerned with gas in the United States, namely, the American Gas Institute and the National Commercial Gas Association. The elimination of the flat-flame burner has been hastened by the urgency of economy in coal during the war. In New York City 20 per cent. of gas consumed is used with open flames, whereas it is remarked that in England not 5 per cent. of the total output of gas is used in this way. Much attention is being given in the United States to the subject of calorific power, and the Gas Commission in Massachusetts has decided to adopt the French standard, viz., 528 B. Th. U. An agitation for the universal adoption of the calorific standard and the abolition of the candle-power standard is now taking place.

The coal shortage has led to the use of some novel materials for the production of gas. An interesting development is the production of gas from straw refuse on the big ranches in North-Western Canada. It is stated that a ton of straw will give 11,000-12,000 cubic feet of gas of 400 B. Th. U., and will yield 6-8 gallons of tar and ammoniacal liquor. In the three prairie provinces of Western Canada alone 20 million tons of straw are available annually, which could be used to produce 140,000 million cubic feet of gas. In France a still more radical departure, the distillation of gas from 5,280 lbs. of spoiled flour is recorded; 11,200 cubic feet of gas and 1,584 lbs. of coke, practically ashless, were obtained. Mixtures of coal gas and natural gas have also been studied. Attention is also drawn to the experiments conducted in this country with gas of very low calorific value, namely, only 350 B. Th. U.

### Incandescent Electric Lamps.

Reference is made to various developments in filament manufacture, notably the process for producing a continuous crystal of tungsten in place of ordinary drawn wire. The resultant filament is said to be very malleable and to remain mechanically strong after 1,200 hours burning, without any appreciable black deposit in the bulb. The crystallisation process is apparently facilitated by the admixture of a small amount of thorium oxide. Attention is also drawn to the multi-filament tungsten lamp recently mentioned in this journal.*

### Developments in Fixtures, etc.

A feature during the last year has been the production of many types of fittings consisting of a combination of indirect and direct lighting. For some time there has been a tendency in general lighting to avoid central chandeliers, and this development has in some cases been carried further by the elimination of wall-fittings as well, thus leaving both walls and ceilings completely free from wiring. The artificial light is then provided exclusively by a series of portable indirect pedestal units, supplementary direct local lighting being afforded by small shaded table lamps.

### Daylight Saving.

The daylight saving measures adopted in the United States appear to have given satisfaction, and it has been urged that it should be made a permanent annual feature. The saving of coal resulting is relatively small, but the social and hygienic advantages are manifest. In Hawaii a committee has been appointed to further the adoption of the system, and it is said that sugar planters on some estates have practised it for some years.

* August, 1918; page 194.

## A PHYSICAL STUDY OF THE INCANDESCENT MANTLE.

A communication on the above subject by H. E. Ives, E. F. Kingsbury and E. Karrer appears in the *Journal* of the Franklin Institute.* The contribution summarises a very comprehensive series of investigations which extend the work of Rubens on thoria-ceria mixtures and other similar materials, such as thoria-uranium oxide, thoria-lanthanum oxide, etc. The curves of spectrum emission with varying constituents are presented, and the important relation between composition and radiant efficiency is portrayed. Thus it is shown that the value L/R (luminous energy divided by total radiant energy) attains 0.0045 with a cerium content of less than 1 per cent. and falls progressively with increasing percentages until ultimately it reaches a value far below 0.001 with 30—90 per cent. ceria. It is shown also that the curve of spectrum distribution differs considerably from the non-selective radiation of a black body at high temperatures, a very marked peak being present in the infra-red near $4.5\mu$. Similar data are given for many other combinations, but it is to be noted that the radiant efficiency appears to be invariably less than that of the best thoria-ceria combination.

The maximum efficiency is apparently attained with 0.75 per cent. ceria and is then over three times that of a black body at the same temperature. This applies to the mantle as a whole; for the brightest point of the mantle the efficiency is about twice as great. Of special interest is the general discussion of the factors which impose limitations as mantle-efficiency. We may secure high efficiencies by varying either the temperature or the constitution of the mantle. With ordinary illuminating gas and the normal range of pressure common in commercial practice the highest attainable flame-temperature appears to be near 2,000° K, which is relatively low, being, in fact, about the same as that of the carbon filament in an electric incandescent lamp. The radiant efficiency of a black body at this temperature is about $\frac{1}{2}$ per cent., and to raise this value we must have recourse to a radiator with pronounced selective emission. An efficiency twenty times greater could apparently be obtained at 3,000°, which is estimated to be about the temperature of the gas-filled electric incandescent lamp. In this case it would, however, be possible to use beneficially a higher ceria content, and thus to attain an efficiency far beyond that of any other illuminant. Thus the relatively low-efficiency radiant of the mantle is chiefly a consequence of the low temperature of incandescence obtained.

This, however, raises the question of the effect of higher temperatures on materials used in mantles. The melting point of thoria has been given as 2,440° C. (2,713° K), and that of ceria as 1,950° C. (2,230° K). Ceria, however, appears to begin volatilising at the ordinary mantle operating temperature; the more rapid deterioration of high-pressure gas-mantles is probably due in part to the higher temperature and consequent more rapid volatilisation of ceria. There is also the physical structure of the mantle to be considered. The lighter the structure the higher temperature it can take, and the exact compromise between durability and efficiency must be determined by practical considerations.

Assuming perfect freedom in the selection of materials, it is deduced that it is theoretically possible with the incandescent mantle to arrive at a radiant efficiency of 13 per cent., and, with the most efficient possible conditions in the Bunsen burner, at a total luminous efficiency of 2.6 per cent. While over thirteen times that at present attained with the normal mantle, it is still low from the standpoint of absolute efficiency (being, in fact, less than that reached in the nitrogen-filled tungsten electric lamp). There is, therefore, a most promising field for further investigation.

* November, 1918.

## NEW LUMINOUS SIGNALS ON THE METROPOLITAN RAILWAY.

The *Railway Gazette* gives some interesting items of some new "position-light" signals being introduced on the Metropolitan Railway. The signals do not depend upon colour, but consist in an arrangement of white lights which can be switched on in groups so as to form horizontal, vertical or inclined lines. It is thus essentially a semaphore-effect, but it is produced by switching on stationary lights instead of by a moving semaphore arm. In this way the "danger," "caution" and "clear" signals are given.

The signal consists of a metal frame, with suitable apertures carrying lenses behind which small filament lamps (about 12 v. 6 c.p.) are accurately centred. The installation has been tried at Willesden Green, and it is stated that the visibility of the lights, even in bright daylight, is quite satisfactory. Thus on one day, in spite of a decided haze in the air, the lights were distinctly visible from Kilburn platform, 890 yards away.

The advantages of the signal are that there are no moving parts, the lights being electrically controlled by four conducting leads and appropriate switches. The signal is clear and definite, there is no heavy working or irregularities due to contraction or expansion of signalling wires (as in a mechanical system), and there is, within limits, no restriction as regards distance, and thus no difficulty in selecting the best position for the signal.

Such signals have been in use on the Pennsylvania Railway in America for some time, and, according to Mr. Rudd, the Signal Engineer of this Company, they can be operated with half the electrical energy necessary when reliance is placed on the use of red, yellow and green lenses. There is also the incidental advantage that the signal is free from any possibility of misinterpretation due to abnormal colour-vision on the part of the driver.

## SEARCHLIGHT PROBLEMS.

The following statement of searchlight problems that demand solution has been prepared by Captain C. Lichtenberg, of Washington, and appears in the *Electrical World*:

(*a*) Means for determining the finding power of a searchlight which will take into account the colour of the light, the nature and colour of the target, the condition of the atmosphere, and the distance between the searchlight, the target, and the observer.

(*b*) Means for rapidly determining the intrinsic brilliancy of a searchlight light-source.

(*c*) A simple system of remotely controlling the operation of a searchlight in azimuth and elevation. The present or proposed systems require from five to fifteen or more wires and are too complicated.

(*d*) A mirror design which shall be more efficient for anti-aircraft service than the standard parabolic mirror.

(*e*) A light source which shall be more efficient than a high-intensity carbon arc. A thallium arc has been suggested because it has only one line (green) in the spectrum.

(*f*) A mirror material which shall have the reflecting and longevity properties of silver-backed glass without the fragility of glass mirrors.

## MEASUREMENT OF TRANSMISSION FACTORS FOR DIFFUSING GLASSES.

In the *Journal* of the Franklin Institute Messrs. M. Luckiesh and H. E. Mellor describe a method of determining the transmission factors for various glasses, both for a narrow beam of light and for uniformly diffused light. As a rule the latter has a lower value than the former (if the narrow beam is directed perpendicularly on the specimen). Another point of interest is that transmission factors are usually greater when the rough surface of the glass faces the light than when the smooth surface does so.

# TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

## SILICA LIGHTING GLASSWARE.

It will be recalled that in a recent issue we referred to the exhibit of transparent quartz glass at the British Scientific Products Exhibition by the Silica Syndicate, Ltd. We referred then to the qualities of such glass which render it specially suitable for laboratory work, where high heat-resisting power is needed. We have now received some further information from the Thermal Syndicate, Ltd. (28, Victoria Street, London), who manufacture similar transparent quartz glass and a translucent quality. The latter variety is of considerable interest to the illuminating engineer and received much attention shortly before the war. It may be recalled that such glass was employed in the new Keith Blackman silica cup high-pressure lamp, and also, we understand, by many gas companies as cylinders for low-pressure lighting. It appears that the properties of the two glasses are precisely similar in all respects, with the exception that the perfectly transparent variety is made from rock crystal, which flows readily at working temperatures; whereas the translucent variety is made from sand, which only attains a plastic consistency when fused, so that the minute bubbles of air are unable to rise to the surface, with the result that the material has a cloudy appearance.

Owing, however, to its great resistance to heat, chimneys of much smaller diameter can be employed than is the case with ordinary glass, resulting in a higher mantle temperature and consequent increased candle-power. Arrangements are being made for the production of these chimneys on a large scale, and we understand that already several gas companies in the North of England are fitting a number to their maintenance lamps. It is claimed that careful tests prove that these chimneys are more economical, notwithstanding their comparatively high initial cost, than the pre-war Continental glass cylinders. Provided cylinders of correct design are employed the slight opacity may, it is stated, be disregarded, for the glassware really acts as a diffuser, and thus has the useful property of diminishing glare from very bright incandescent surfaces, such as mantles or filaments.

## A TEMPLE OF HYGIENE.

We are informed that a number of influential medical men are interesting themselves in a proposal to build a Temple of Hygiene in the centre of London so as to provide better facilities for the work of the Institute of Hygiene. Attention is drawn to the paramount importance of safeguarding the health of the nation, which renders this a fitting peace memorial. No doubt among the other factors essential from the hygienic standpoint the importance of adequate lighting from the standpoint of health and efficiency will receive due consideration. Sir Malcolm Morris has consented to act as Chairman of the Committee, and Sir Samuel Scott, Bart., M.P., is the Hon. Treasurer. We wish the project success.

## WARDLE ALL-BRITISH FITTINGS.

The new catalogue issued by the Wardle Engineering Co., Ltd. (Manchester), is an interesting indication of the trend of events in lighting accessories. It is recognised that no lamp is now complete without its appropriate globe or reflector, and in industrial lighting especially much is lost by neglecting to attend to the proper distribution of light. The catalogue before us contains a number of units specially adapted for workshop lighting, a typical reflector for use with half-watt lamps being shown in Fig. 1, while Fig. 2 illustrates a semi-indirect fitting. There are now available metal reflectors of the focussing, intensive and extensive types for half-watt lamps, while the angle type should be very serviceable for lighting large vertical or inclined surfaces.

The catalogue also contains illustrations of the " inverlite " units which are readily applied to office lighting. Finally there is a series of special lanterns for half-watt lamps, many of which are specially designed with a view to the lighting of streets, docks, railway yards, and large open spaces. The catalogue is conveniently arranged with illustrations and specification data on the left, and an indication of the polar curve of the unit on the right. At the commencement there is an up-to-date summary of the essentials of good works lighting, definitions are given of the chief photometric units, and some useful tabular data are presented. It is remarked that approximately 200,000 accidents are estimated to occur annually in British workshops, the majority of which take place during hours of more or less imperfect artificial lighting. The remedy, therefore, is to instal a thoroughly adequate system of illumination. We are glad to note an example of the use of the lumen in calculations, as showing how this term is being familiarised by leading firms concerned with illumination.

FIG. 1. Typical Workshop Lighting Reflector for Gas-filled (" Half-Watt ") Lamps.

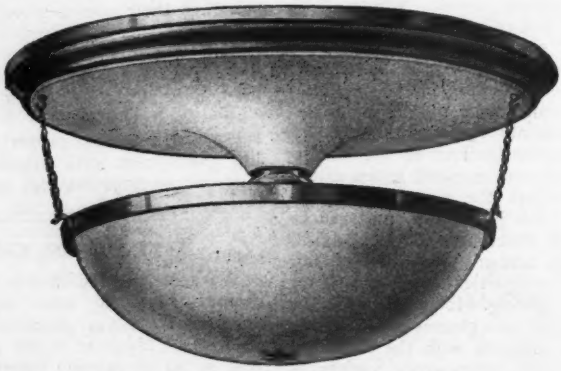

FIG. 2. Semi-indirect Fitting, Adapted to either Vacuum or Gas-filled Lamps.

## THE IMPROVEMENT OF MACHINE LIGHTING BY THE USE OF WHITE PAINT.

A good overhead system of lighting is the modern standard for industrial establishments, and usually provides all the light that is required for the lighting of most interiors. Frequently, however, local lighting is employed in addition to the overhead lighting for certain machines or locations in the shop.

We are indebted to the British Thomson-Houston Co., Ltd., for some particulars of an interesting example of the use of white paint to assist such local lighting. A large machine-room containing massive vertical slotters was lighted with an overhead system to an average intensity of about 2 foot-candles. The heavy machines were finished with very dark paint, so that the lighting of the tables in the region where the cutter operated was insufficient for setting the cutter accurately to the pencil markings on the rough castings ready to be machined. As a remedy a lamp on a drop cord was provided for each machine, and the surfaces of the machine which faced the table were painted white. This improvement avoids any shadows from the local lamp as the reflection from the white-painted surfaces softens the shadows very materially, and increases the illumination on the table by about 75 per cent. Thus (as indicated in Fig. 1) the foot-candle meter readings taken at the base plate showed an improvement with the use of paint of 100 per cent. in the lighting at the points A and C, and over 50 per cent. at the point B.

Owing to the present necessity for strict economy by reason of the coal restrictions, the use of white paint would appear well worth consideration in machine and work shops.

This is, of course, only one among many possible illustrations of the value of good light-reflecting surfaces in workshops. The importance of light walls and ceilings is well known, and attention has also been drawn to instances in which a white concrete floor gave material assistance to the diffusion of light.

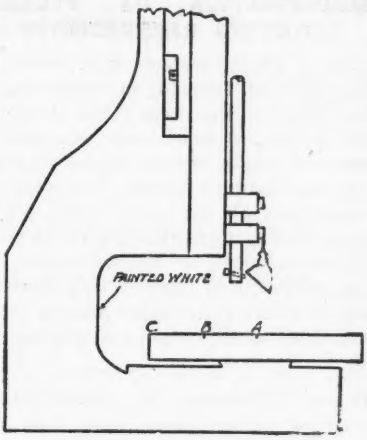


FIG. 1. Diagram of machine showing the improvement in lighting obtained by painting the vertical surfaces of the machine facing table.

## REMOVAL OF FLAT-FLAME GAS-BURNERS IN THE UNITED STATES.

The movement towards the substitution of incandescent for flat-flame gas-burners in the United States, to which reference was recently made in this journal,* seems to be making steady progress. The *Gas Age* quotes several instances of cities which have almost completely eliminated flat-flame burners. Thus at Bisbee, Arizona, as a result of the recent campaign, the only burner of this type still existing is said to be one in the offices of the local company for testing purposes. In Newark a Gas Mantle Week is being arranged, and Mr. T. L. Richmond, director of streets and improvements, has issued an appeal to consumers " to save gas, money, and coal " by installing modern incandescent burners. The movement is parallel to that in this country, where, as is well known, flat-flame burners now form only a very small proportion of the total number of burners in daily use.

*ILLUMINATING ENGINEER, September, 1918, p. 216.

## MODIFICATION OF STREET-LIGHTING RESTRICTIONS.

In an official announcement issued on November 12, following the concluding of the armistice, the Home Office state that the masking of street lamps may now be removed, but in view of the coal shortage the total number of lamps in use must not exceed one-half the normal. The restrictions relating to the shading of lamps in houses and shops are also withdrawn, but the prohibition of lights in shop windows and of advertisement lights must be maintained on account of the coal shortage.

In reply to various questions in the House of Commons Mr. Brace, besides referring to the above steps, also announced that instructions had been given that trams and omnibuses might resume normal lighting except that, in the interest of safety, the canopy lights and headlights on trams should not at present be increased. The general question of lights on vehicles, including motor-car headlights, was receiving attention. (An announcement has since been made modifying the war-time restrictions.)

With reference to the New Lighting Restrictions Order for Ireland*, Mr. Shortt stated that, in view of suggestions made to the authorities, an Amending Order was in course of preparation and would be issued shortly.

Another point was recently raised in the House of Commons regarding the waste involved in screening arc lamps of high candle-power in certain districts, whereby only a small fraction of light was allowed to escape on the roadway. It was suggested that incandescent electric lamps of smaller consumption should be substituted.

Sir Albert Stanley undertook to have the matter looked into.

* See ILLUMINATING ENGINEER, September 1918, p. 218.

## RESTRICTED PUBLIC LIGHTING AND ADVICE TO PEDESTRIANS.

With a view to obviating an increase in the number of accidents to be anticipated consequent upon the restrictions in public lighting prevailing during recent months, a series of useful instructions was issued by the London Safety First Council for the benefit of pedestrians in the streets after dark. The recommendations, which deserve attention as of permanent value, are as follows :

1. LOOK TO THE RIGHT before crossing the road.
2. CROSS THE ROAD FROM A STREET LAMP. See and be seen!
3. MAKE FULL USE OF STREET REFUGES. They are "Isles of safety."
4. ALWAYS FACE APPROACHING TRAFFIC, *i.e., never* step off the footpath with your back to oncoming vehicles.
5. HOLD OUT A WHITE HANDKERCHIEF when crossing the road, to attract drivers' attention and to indicate your whereabouts.
6. PAUSE BEFORE CROSSING THE ROAD upon leaving brightly illuminated premises. *Remember* the sudden change to darkness causes momentary blindness!

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F. NORIE-MILLER, J.P.
*General Manager.*

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## INDUSTRIAL ACCIDENTS.

We have received from the British Thomson-Houston Co., Ltd., some interesting information bearing on the relation between illumination and industrial accidents.

As showing the value of good lighting in connection with the reduction of accidents, the following results obtained from records of the Travellers' Insurance Company of the United States are specially mentioned.

Of 91,000 industrial accidents recorded in 1910 23.8 per cent. were due directly or indirectly to poor lighting. It should be noted that this record refers only to the accidents investigated by this one Insurance Company. For the same period an estimate is made that puts the total industrial accidents of the United States at 500,000, and, on the basis of the Travellers' Insurance Company's percentages, about 125,000 of these accidents were chargeable to the lack of proper illumination eight years ago. Since that time Insurance Companies have studied lighting conditions in factories in order to classify the risk, and, as proper lighting resulted in lower premiums, it was not long before factory managers and their engineers worked out better methods of illumination.

The result of this is that during the last two or three years the improvements in lighting have caused a reduction of at least 30 per cent. in accidents which are chargeable to the lack of proper illumination.

## THE WELFARE OF THE WORKER.

We are informed that the Institute of Hygiene has decided to form an Industrial Council, representative of both capital and labour and medical experts, as a special section of the General Council. The object of this industrial council will be to investigate the diseases and disadvantages under which the worker labours, and to prevent them by promoting and spreading a better knowledge of the hygienic measures necessary. It is pointed out that good housing and surroundings and proper foods and feeding are of equal importance, and that recreation or mental hygiene deserve careful consideration in order to maintain the health and fitness, and secure the best energies, as well as the contentment of the worker.

# REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED

*"Reconstruction Problems: A New Field for British Engineering." (Issued by the Ministry of Reconstruction. Price 2d.)*

In March, 1916, a Committee was appointed by the Board of Trade to "consider the position of the engineering trade after the war, especially in relation to international competition, and to report what measures, if any, were necessary or desirable to safeguard the position." The problem involves special consideration of labour conditions and in this connection it is pointed out that: (1) No new industry should be introduced into the country that would not ensure to all employed in it a wage compatible with an adequate standard of living and unless machinery exists or be set up for regulating the rate of wages and hours of labour. (2) No new industry should be introduced which exposes those engaged in it to special risk of industrial disease.

A list of a considerable number of trades was drawn up and is being dealt with by representative committees. Among the subjects mentioned are: Machinery for making wire, paper and leather, and printing, textile, and agricultural machinery, aircraft, electrical and scientific instruments, machine tools, the motor industry, &c.

The Government have decided to set up a Committee of Ministers to decide questions of post-war priority and allocation, and it is anticipated that the engineering trades will be amongst those benefiting most from this organisation.

## BRITISH SCIENTIFIC PRODUCTS EXHIBITION.

In view of the wide public interest taken in the above exhibition the British Science Guild has decided to organise a similar exhibition next year. Meantime a large part of the recent exhibition has been transferred to Manchester, and has been on view at the Municipal College of Technology.

# 11

The ILLUMINATING ENGINEER

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# EDITORIAL.

## Progress in Photometry and War Problems.

The opening meeting of the Illuminating Engineering Society during the present session was appropriately given up to a summary of progress in photometry since the outbreak of war. By permission of the Ministry of Munitions, an account was given by the President, Mr. W. C. Clinton, and others of the methods adopted by two Committees of the Society dealing with the illuminating value of flares, parachute lights, etc., and the brightness of self-luminous radio-active paint. We give on pp. 249-263 an account of these two papers, the subsequent discussion being reserved for our next issue.

One of the most interesting features of this discussion was the complete contrast presented by the two main lines of investigation. In the one case we are dealing with sources of light yielding up to 120,000 candles, but only of short duration, and fluctuating widely during this short period. In the other we are concerned with feebly luminous paints which decay in brightness very gradually, so that a complete investigation covers months or even years. Special forms of photometers had to be designed for the

researches, and these, while specially adapted to the purposes the Committee had in view, will no doubt lead to other developments in time of peace. Naturally it was only possible to deal with the problems in general terms, and for the present various pieces of confidential information cannot be disclosed. Enough was said to illustrate the great practical value of these experiments to which appreciatory references were made by Captain Gray and Mr. Bryson, speaking on behalf of the branches of the Ministry of Munitions concerned with these investigations.

In the experiments on flares the problem resolved itself into a comparison of sources of light which fluctuated so rapidly that it would hardly have been possible to get satisfactory readings with an ordinary illumination-photometer, requiring manipulation to get balance. Accordingly the Committee devised a form of instrument which could be read at a distance by the mere inspection of a series of letters of graded brightness, the average of many sets of readings being taken, and the result ultimately reduced to the form of "candlepower-seconds per gramme of composition." In this way many different types of flares, parachute lights, etc., were compared. This type of instrument would appear to possess substantial advantages in other branches of illuminating engineering work. For example, the fact that it can be studied simultaneously by a number of observers should make it very useful for demonstration purposes at lectures and in the showroom. One could, for example, readily show in this way the improvement in illumination that results from the use of a suitable reflector to redirect the rays of light from a bare lamp. Smaller instruments of a pocket type would doubtless be useful in taking rapid rough measurements of illumination in vehicles, on railways, and in other crowded places.

The form of photometer described by Mr. Clinton also should prove of considerable interest in its bearings on measurements at very low illuminations. The difficulties of working at such a feeble luminosity, with such minute objects, and with light of such a peculiar colour, will be appreciated by all having experience of photometry and the consistency of the results reflects great credit on the investigators. We believe that there is a great field for further photometric experiment on fluorescent and phosphorescent phenomena. In this wide field of research, most promising for the future, the refined appliances now available for light-measurement have been but little used in the past. This investigation shows how useful they may prove in the future. While the practical applications of such materials have been somewhat limited hitherto, on account of the high cost of material and relatively weak luminosity so far attained, it is quite possible that there may be interesting developments in the future. Radio-active self-luminous paints, and other forms of fluorescent and phosphorescent media have found many special applications in the war, and the great amount of patient experiments bestowed on them has already led to marked improvements in brightness and permanence.

There were many other interesting points raised in the discussion, consideration of which must be deferred until our next issue. These investigations provide a striking illustration of the special applications of light-measuring apparatus in time of war—a development which was only rendered possible by the long preparatory work carried out by the Society in previous years. We believe that the information acquired in these tests will also prove of considerable value in relation to future progress in photometry.

## Illuminating Engineering and Aerial Navigation.

While the problems connected with the use of flares and parachute lights studied by the Committee of the Illuminating Engineering Society referred to above had reference primarily to the requirements of the war, it seems likely that equally useful extensions of such work might be made in relation to the aerial traffic of the future, in the service of peace. The use of such lights for conveying signals will doubtless be associated with aerial traffic, and the carrying of fixed lights will also require careful study. Questions relating to the visibility of distant coloured lights, to which Captain Gray referred in the discussion, will assume special importance. In this way there may develop a new branch of illuminating engineering—the use of light to assist navigation in the air.

We have before us a very interesting Report issued by the Civil Aerial Transport Committee, in which many important problems—the sovereignty of the air, the rules of air-traffic, and the international procedure to govern such traffic, are discussed. Of special interest is the reproduction of the recommendations of the International Convention in regard to Aerial Navigation, held in Paris in 1910, with which the Committee are generally in agreement. This document makes a start towards the prescription of lighting matters by defining the lights to be carried by aircraft when flying by night, and the nature of luminous distress signals. It is evident, however, that the exact nature of these lights, and particularly the requirements necessary to secure adequate visibility and distinctive features will require more detailed study. It is also laid down that an air vessel must carry a plate descriptive of its ownership and domicile, with an appropriate registration number, in the same manner as a motor car, and also an official mark of nationality. These emblems will require to be lighted by night, and their dimensions and brightness should be specified.

These, however, are only a few of the many points to be considered in night flying. Of equal importance are the lighting of landing places and the luminous descriptive devices to be applied to aerodromes. The Committee foresee the necessity of subjecting the route-marking methods of commercial companies to central control in order to avoid confusion. Ultimately international air-traffic will require a system of lights as powerful, and much more adaptable, than those employed to mark our coasts and seas for ocean-going vessels. For whereas lighthouses, buoys, etc., need only be visible in a horizontal plane, aerial light-signals must be visible from any quarter. Yet another important matter will be the correlation of visible signals and devices with information conveyed through sound-waves. Wireless telegraphy, and probably also wireless telephony, will doubtless play a most important part in aerial traffic.

In the elucidation of all these problems involving the study of brightness, visibility, and colour, appropriate methods of measurement will be valuable, and the problems will be substantially similar to many others which have come before the Illuminating Engineering Society. We foresee, therefore, an important field for the Society's work in connection with the coming development of aerial navigation.

## Industrial Fatigue Research.

The appointment, by the Department of Scientific and Industrial Research and the Medical Research Committee, of a Research Board to deal with the question of industrial fatigue is a step of great importance. The field of work comprises a general survey of the relations of hours of work and other conditions of employment to the production of fatigue, having regard both to industrial efficiency and the preservation of health among the workers. It is understood that the Board will initiate and organise researches in different industries on all such problems, and will endeavour to secure the co-operation of both employers and workers in their solution.

At the present moment the study of industrial fatigue is of vast importance. We have come through a period of great strain and stress, when the adaptability and resources of the factories have been taxed to the utmost. We have learned much in the direction of measures to promote higher efficiency, and we have seen also how vital it is that in aiming at better and quicker production we should avoid conditions which occasion fatigue, are highly prejudicial to the health of the worker, and inevitably lead to diminished efficiency.

Of chief interest is the influence of inadequate lighting in accelerating fatigue. The exposure of brilliant unshaded lights in the range of vision, or the trying forms of glare arising through reflection of light off polished material, are recognised to be wearisome to the eyes, and probably productive of defects in vision, besides causing general fatigue. But the effort to carry out fine work by insufficient illumination or by the light of improperly placed lamps which shine direct into the eyes or cause inconvenient shadows also constitutes an important element in fatigue. Mr. Stanley Kent's researches have shown, by precise tests, how the alertness and physical state of workers tends to deteriorate progressively during hours of work. We feel sure that inadequate lighting must hasten this decay in efficiency. Of special interest is the question of the amount of illumination necessary to secure maximum efficiency in different industrial processes. The striking experiments recently described by Mr. W. A. Durgin in Chicago, which were referred to in our last issue*, show how powerfully an increase in illumination may operate in improving output and quality of work.

The carrying out of such experiments in factories would naturally require the full co-operation of the employer, but we feel sure that once it is recognised that the tests will give results of immense value both to the management and the workers, their assistance will be freely given.

No doubt all such questions will receive the sympathetic consideration of the newly-formed Board. Professor Sherrington, the Chairman, and Mr. D. R. Wilson, the Secretary, are also members of the Department (Home Office) Committee on Lighting in Factories and Workshops, and are thus in a position to appreciate the great importance of good lighting. We trust that the Committee will, through specific researches, be able to produce further confirmatory evidence to establish the relation between light and vision and thus support the strong and general belief in the desirability of adequate illumination in the interests of safety, health, and efficiency of work.

LEON GASTER.

* October, 1918, p. 229.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

*The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.*

# PROGRESS IN PHOTOMETRY WITH SPECIAL REFERENCE TO WAR PROBLEMS.

(Proceedings at the first meeting of the Session, held at the Rooms of the Royal Society of Arts London, at 8 p.m., on Thursday, December 19th, 1918.)

THE opening meeting of the session was held at the House of the Royal Society of Arts (18, John Street, Aldephi, London, W.), at 8 p.m., on Thursday, December 19th, THE PRESIDENT (Mr. A. P. TROTTER) in the Chair.

The Minutes of the last meeting having been taken as read, the names of the following applicants for membership were announced :—

| | |
|---|---|
| Brymer, R. | Managing Director of the Britannia Lamp and Accessories Co., Ltd., 48, Milton Street, London, E.C. |
| Dennison, F. S. | Messrs. Siemens Bros., Dynamo Works, Ltd., 39, Upper Thames Street, London, E.C. |
| Ely, M. V. | Chairman and Managing Director of the Foster Engineering Co., Ltd., Morden Road, Wimbledon, S.W. |
| Gould, F. J. | Chairman of Directors, The Bland Light Syndicate, Ltd., 29, Little Trinity Lane, London, E.C. |
| Higginbotham, J. | Britannia Lamp and Accessories Co., Ltd., 48, Milton Street, London, E.C. |
| Sturgeon, A. J. | Manager of the Foster Engineering Co., Ltd., Morden Road, Wimbledon, S.W. |

The HON. SECRETARY then presented the usual **Notes on Events during the Vacation** (pp. 251—252), in the course of which he referred to the work done by the Society in affording guidance on economy in lighting, the problems that had come before the Lighting Sub-Committee of the London "Safety First" movement in connection with street-safety, and the formation of the British Industrial Safety First Association. Allusion was also made to the claims of good illumination in factories, as illustrated by the legislation adopted by certain of the United States of America, to the British Scientific Products Exhibition held in London in August, 1918, and to the approaching resumption of normal lighting conditions following the conclusion of the armistice.

The PRESIDENT made a few introductory remarks on the conditions arising through the termination of hostilities, in the course of which he alluded to the decision taken by the Royal Society regarding future international relations between scientific societies. He then proceeded to read his paper on "**Photometric Apparatus for Measuring the Illuminating Value of Fluctuating Sources of High Candlepower**" (Flares, Parachute Lights, etc.) (see pp. 253—259). He explained how that the testing of various flares and flashlight compositions had been undertaken by a Committee of the Society for the Ministry of Munitions, by whom permission for some account to be given of the methods employed had kindly been granted. Two special photometers designed for this work were exhibited at the meeting and described. The President also gave a brief summary of the procedure followed in testing flares at experimental grounds in the vicinity of London, results being subsequently reduced in the form of candlepower-seconds per gramme of composition.

Mr. W. C. CLINTON, in a paper entitled "**Some Photometric Tests of the Brightness of Radio-active Self-luminous Materials**" (see pp. 260—263), summarised the results of a series of experiments, also conducted for the Ministry of Munitions, on self-luminous compounds containing respectively 0·8, 0·5, 0·4, 0·3, 0·2 and 0·1 mgm. of radium bromide per grm. of material. The experiments extended over a year, and diagrams illustrating the decay in brightness during this period were presented. Another point investigated was the effect of depth of material. In view of the high cost of radium, the experiments had been of great utility in determining the minimum of this material which could be usefully employed.

In the ensuing discussion, Mr. J. S. Dow, Mr. C. C. PATERSON (Nat. Phys. Lab.), Captain GRAY (Chemical Warfare Dept., M.O.M.), Mr. F. F. S. BRYSON (M.O.M.), Mr. F. HARRISON GLEW, Mr. J. W. T. WALSH (Nat. Phys Lab.), Mr. A. BLOK (M.O.M.), Mrs. H. AYRTON, Mr. L. GASTER and the PRESIDENT took part.

The discussion ranged over a variety of topics. Mr. J. S. Dow referred to the value of one of the photometers described by the President for demonstration purposes, and showed a pocket form of apparatus devised on similar lines. He also exhibited an experimental form of illumination photometer in which the usual glow lamp fed by a battery was replaced by a patch of luminous paint, and the light from the surface tested dimmed by a graded absorption wedge. Mr. C. C. PATERSON discussed some problems in connection with specifications for gas-filled electric incandescent lamps, arising from the colour of the light and the fact that watts per candle were not necessarily a criterion of temperature. He suggested a form of acceptance diagram based on the maintenance of a temperature similar to an agreed value for vacuum glow lamps.

Captain GRAY, speaking on behalf of the Chemical Warfare Dept. of the M.O.M., referred in appreciatory terms to the work of the Committee of the Society conducting experiments on flares. Trials had shown that British flares were superior to those used by our adversaries Captain Gray also referred to various problems encountered in selecting colours for signalling purposes. Mr. F. F. S. BRYSON, on behalf of the Optical Branch of the Ministry of Munitions, likewise expressed the thanks of this department for the work carried out. He mentioned particularly the valuable results arrived at in connection with the brightness of self-luminous radio-active compounds. Mr. F. HARRISON GLEW referred to various details in the testing of radioactive compositions, and Mr. J. W. T. WALSH dealt with several special problems which had been studied at the National Physical Laboratory during recent years. Special reference was made to the testing of mean spherical candlepower in a cubical integrating photometer, of which they had had very favourable experience. Various points in the operation of this apparatus were also dealt with by Mr. A. BLOK, Mrs. HERTHA AYRTON, and others.

The PRESIDENT, in winding up the discussion, announced that the **next meeting** would take place on **January 21st, 1919,** when a discussion on "**Modern Practice in Office Lighting**" would be opened by **Mr. A. Wise.**

# NOTES ON EVENTS DURING THE VACATION

By L. GASTER (Hon. Secretary).

(Presented at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 8 p.m., on Thursday, December 19th, 1918.)

It is customary at the first meeting of the session to give some account of progress during the vacation.

In accordance with the arrangement entered into with the Institutions of Gas and Electrical Engineers, the President of the former institution, Mr. Samuel Glover, has kindly consented to become a Vice-President and Member of Council during his tenure of office, while Mr. C. H. Wordingham will continue to act in these capacities, which he undertook on election to the Presidency of the Institution of Electrical Engineers last year.

While, as usual, no meetings have been held during the vacation, there have been various events of interest to the society, and its co-operation has been sought in various matters. The need for economy in lighting, which formed the subject of discussion at the annual meeting, has been increasingly emphasised during the past few months, and endeavours have been made to secure that such economies should be made in the most judicious way, and mainly through the elimination of waste of light. The series of recommendations on this subject, presented at the annual meeting, and especially the schedule of consumptions of gas and electricity and the corresponding illumination for industrial lighting, have proved most useful as a guide to the authorities. These recommendations have also been followed up by the publication in THE ILLUMINATING ENGINEER of a discussion of "The Lighting Ration in Practice," wherein the procedure to be followed in houses of various sizes in order to comply with the new Household Fuel and Lighting Order was roughly indicated.

In regard to street-lighting, the desire for economy also led to a proposition, on the part of certain London boroughs, that a further diminution should be effected during the summer months, and in the month of August the authorities sanctioned a further reduction of 50 per cent., as an experimental measure to effect economy in consumption of coal. It was, however, stipulated that the reduction should be spread equally over both main and side streets, so as to be without prejudice to a uniform lighting effect; and, further, that the measure should be subject to revision should it be found that the reduced lighting led to increases in crime or danger to pedestrians or vehicular traffic, or impeded the supervision of the streets by an already depleted police force. This matter came before the notice of the Street Lighting Sub-Committee of the London "Safety First" Council, when attention was drawn to the above and other important matters.

In view of the prospective resumption of normal lighting conditions, it is felt that the time is ripe for a complete discussion on the subject, taking into account the experience gained since the war, and it has accordingly been decided to arrange for such a discussion during the present session.

The requirements and design of motor-car headlights, which has likewise received attention from the Street Lighting Sub-Committee of the London "Safety First" Council, appears to be another opportune topic for discussion.

The important departure taken at the meeting at the Mansion House, on June 12—namely, to extend the "Safety First" movement to industrial operations—has since taken shape in the formation of the "British Industrial Safety First Association," the first Council meeting of which was held on October 31. Amongst those who have contributed to the success of this useful development, special reference should be made to the services of Mr. F. W. Goodenough, Mr. H. E. Blain, and Mr. Gray. The Illuminating Engineering Society is represented on the Council of this new body, and it is hoped that the relation will be helpful in promoting the study of proper industrial lighting, with a view to the prevention of accidents.

In other quarters the claims of good illumination in factories have also been strongly emphasised—for example, in the Final Report of the Health of Munition Workers Committee, which endorses the conclusions presented in the various bulletins issued from time to time, and includes some striking instances of the results of inadequate illumination. In the United States further progress has been made in legislation dealing with industrial lighting, and there are now five States that have adopted such regulations. The State of Wisconsin, one of the pioneers in this field, has now revised its original Code and adopted very comprehensive regulations, based on the provision of a specified illumination in foot-candles for various classes of work.

In the lighting of cinema theatres, another example of the specification of illumination is afforded by a recent regulation of the L.C.C., according to which the illumination in no part of the hall is to be less than 0.025 foot-candles. It will be recalled that this question was one of those discussed by the Cinema Commission of Enquiry which reported last year, and before which evidence was given on behalf of this Society. During the vacation the Society has been represented on a committee of ophthalmic surgeons and others concerned with the standard of lighting for test-types used in examinations of vision, for the public service. The recommendations of this committee, which are intended to secure that the illumination of such charts shall be uniformly maintained above a specified adequate value, will be issued in due course.

An event of considerable interest was the British Scientific Products Exhibition, promoted and organised by the British Science Guild, which took place at King's College, London, during the months of August and September. The society was represented on a sub-committee to which matters relating to illumination were referred, and progress in illuminating engineering was summarised both in an introductory article in the descriptive catalogue and in a lecture delivered at the exhibition, at which the president took the chair. Through the courtesy of the Ministry of Munitions, the society was able to exhibit some of the special photometers designed by the committee of the society, which has been carrying out investigations for the Ministry on flares, parachute lights, etc. Permission has now been accorded for some fuller particulars of this and other special work to be given at the opening meeting of this session.

The event of outstanding importance during the vacation has naturally been the conclusion of an armistice and the cessation of hostilities, whereby the necessity for some of the restrictions on lighting has already been removed. It is to be hoped that the near future will see the resumption of normal conditions in the lighting industry, which should play an important part in the various problems of reconstruction.

Finally, a word of caution may be given. In the relief at the removal of restrictions that have prevailed during the war, there is a tendency to revert simply to pre-war practice in lighting. Yet we have something to gain from our experience during the last few years, and we should seek not merely to restore the old conditions but to improve on them.

# PHOTOMETRIC APPARATUS FOR MEASURING THE ILLUMINATING VALUE OF FLUCTUATING SOURCES OF HIGH CANDLEPOWER (FLARES, PARACHUTE LIGHTS, ETC.)

BY A. P. TROTTER (*President*).

(Presented at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 8 p.m., on Thursday, December 19th, 1918.)

In August, 1916, our Society was asked by the Optical, Glassware and Munitions Branch of the Ministry of Munitions to take up the work of devising a method and apparatus for comparing the illuminating values of flash lights, flares, star-shell compounds and similar rapidly-burning compositions.

The constitution of the Committee was as follows:

CHAIRMAN. — Mr. A. P. Trotter (Messrs. Handcock, Dykes and Trotter, Consulting Engineers, President of the Illuminating Engineering Society).

SECRETARY.—Mr. Leon Gaster (Hon. Secretary of the Illuminating Engineering Society.)

Mr. Arthur Blok (representing the Ministry of Munitions. O.M.G.).

Mr. Maurice Blood (representing D.I.S.A.A., Royal Arsenal, Woolwich).

Mr. J. G. Clark (Experimental Department, Gas Light and Coke Co.).

Assistant Professor W. C. Clinton (University College, London).

Mr. J. S. Dow (Hon. Asst. Secretary, the Illuminating Engineering Society).

Prof. J. T. MacGregor Morris (East London College).

Capt. G. H. Wicks (representing the Chemical Warfare Dept. of the Ministry of Munitions).

Fireworks have been cited by writers on political economy as an example of purely unproductive expenditure. In its brief career an expensive rocket may delight a large number of persons, but the result is measured only by a chorus of "Oh!"

The object of this research was to make a scientific investigation of the most efficient mixtures and methods of burning, by accurate application of measurement to effects which had never been measured before.

The work had been begun by Mr. K. C. Hickman, of the Chemical Advisory Committee of the Trench Warfare Department, by photographing small samples in a laboratory. A number of successive photographs were taken on a moving plate, and by comparison of these, relative values could be estimated.

It was recognised that the mere measurement of candle-power would not define the performance of an illuminant.

The quantitative part is comparatively simple, the quantity of light depending on the two factors of flux of light and time. The quantitative efficiency of any pyrotechnic mixture is the product of the two factors, candle-power and time, divided by the mass of material consumed. The results were therefore expressed in candle-power-seconds per gramme.

Since the rate of burning is irregular, it was necessary that the photometer should be so constructed that variations of light might be followed and measured at any instant, thus enabling a number of observations to be made at regular intervals.

The qualitative part of the problem

was more difficult, and comprised estimates and attempts at measurements of detail-revealing power in its relation to rapidly-burning flares of great intensity or to lights of less brilliance and longer duration, and to the effect of smoke and of different coloured flames. This part of the problem included the consideration of glare and dazzle which may be an advantage or a disadvantage in different circumstances, also eye-fatigue and after-images.

While the early experiments of Mr. Hickman were in progress, with 6-gramme charges of composition in paper cases about 9 mm. diameter and 80 mm. long, the candle-power was measured by Mr. J. S. Dow with his lumeter. The Committee recognised

Fig. 1.—View of Original Tube Photometer.

that the peculiar conditions called for the construction of a new photometer which should be portable, self-contained, direct-reading and purely inspectional without requiring any manipulation or adjustment during use. It should be suitable for outdoor or indoor work, and no special training or photometric knowledge should be required.

A photometer meeting all these requirements was produced, the design being that of Mr. J. G. Clark, and was only slightly modified by subsequent experience. A second photometer of a different kind was afterwards produced by Mr. J. S. Dow.

The first of these instruments consists of a tube 635 mm. (25 in.) long, and 75 mm. (3 in.) in diameter. The interior is whitened and is illuminated by a small electric glow lamp placed at one end. A slot 50 mm. (2 in.) wide extends nearly the whole length of the tube, and this is covered with a strip of thin metal having perforations in the form of letters or numbered and graduated slits. This strip is painted white and receives the illumination to be measured. Since the interior of the tube is brilliantly illuminated at one end, and but feebly illuminated at the other, the perforations near the electric lamp generally appear to be brighter than the externally illuminated strip, and those at the other end darker. An intermediate point can be estimated where the brightness of the interior of the tube is equal to that of the external strip. It is a somewhat Irish characteristic of the photometer that that letter must be chosen which cannot be seen. In the case of a flickering light the point of balance continually moves.

The illumination corresponding to each perforation is ascertained by calibration in a photometric laboratory. The lamp is supplied by a portable battery, and so long as the voltage is constant the calibration may be depended upon.

The lamp is shown dotted in the general view of the instrument in Fig. 1, and a side view is given showing how the lamp is placed.

It might seem that a number of slits forming a grid, as in the photometer invented in 1894, would be better, but this is not the case. It would be necessary to choose the disappearing slit and then to read its number on a graduated scale. Perforations in the form of numerals suggest themselves, but beyond the ninth, double numerals would have to be used. Letters are therefore better, but the great advan-

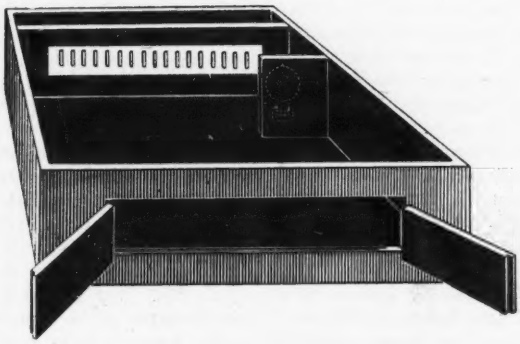


Fig. 2.—View of Supplementary Flare Photometer.

tage which they offer over numerals is that the names of all but W are monosyllabic and they can be dictated clearly and rapidly by an observer, who never takes his eyes off the instrument, to an assistant who writes down the readings.

The illumination falls off rapidly at the bright end and changes gradually at the darker end. This is rather a disadvantage. Several attempts were made to remedy it.

The second instrument (Fig. 2) consists of a light wooden box 280 mm. (11 in.) by 280 mm. (11 in.) by 102 mm. (4 in.) deep. The observer looks through an opening cut in one side of the box and sees on the farther side a grid of 14 slots cut in white paper or card. The grid is illuminated by a small electric lamp placed on one side in the box, and screened from the observer. The illumination of the grid therefore is graded like the interior of the photometer already described.

Observation is made by looking through the slots at a detached test screen which receives the illumination to be measured. As in the other photometer, a point can generally be found where the brightness of the slotted card appears to be equal to that of the test screen seen through a certain slot. A graduated scale gives a measure of the illumination thus determined.

Unlike the other instrument, a range much wider than that afforded directly by the slots is obtained by using test screens of various tints of grey. As a rule a white screen 300 mm. (18 in.) long and 102 mm. (4 in.) wide is placed at a distance of about 1 metre. If the observer finds that the balancing point is near the darker end of the scale he can at once direct his view to an adjacent screen of a grey tint. The balancing point becomes shifted to the other end of the scale. Each tint has a definite multiplying factor found by experiment.

The earliest experiments were carried out in a laboratory at the Imperial College of Science, South Kensington, and on one occasion, after due notice had been given to the police and to the Fire Brigade, tests of flares were made out of doors between the College and the Museum. On three nights in March, May, and June, 1917, experiments were carried out at an experimental ground in London and afterwards on six nights at a similar ground outside the Metropolitan area.

The duties of the different members of the committee were carefully organised on the working nights. Some observed the photometers, others recorded the dictated letters, others took charge of and served out the stock of samples, taking care that the descriptions were duly entered on the printed record sheets. One with a stop-watch sang out the seconds from the moment of ignition. The observers generally dictated a letter at intervals of two seconds. Fig. 3 gives some specimen time records. There were several different time-characteristics. Some flares start with a brilliant burst, others show a distinctly rhythmical effect.

The samples were generally attached to a cord and hauled up to a cross-arm on a pole, and burned, pointing downwards at a height of from 8 to 20 feet from the ground. Two cords and pulleys were provided so that no time was lost. The photometers, generally two of the Clark pattern, were set up at a distance appropriate to the probable candle-power of the flares, and were watched from a distance of 8 to 10 feet by several observers simultaneously, while Mr. Dow generally worked with his lumeter as a check.

On some bitter nights the observers had a trying time with cold wind, clouds of smoke and an occasional shower of sparks, and envied those whose lighter task it was to stamp up and down with hands in pockets observing the scenery generally. This work of judging "detail revealing" power is one which can only be carried out effectually by an experienced soldier or sailor. While the photometrists busy themselves with tapes for measuring distances, with inverse squares, angles of elevation, cosines, voltage of batteries, and tedious working out of results on the following day, the "de-

tail revealing " is a matter of judgment during the few seconds of the burning; and the result is not expressed in decimals but as " good, fair, poor, bad," or any qualified degree of badness which fits the case.

Working nights in winter have the advantage that the tests can be begun early and there is a chance of catching a train for home. On one occasion the work was not over until about 4.30 a.m., when our worthy Honorary Secretary and other members of the committee had a couple of hours sleep on the floor of the laboratory at the testing station and turned up at their respective offices for their daily work at the usual time.

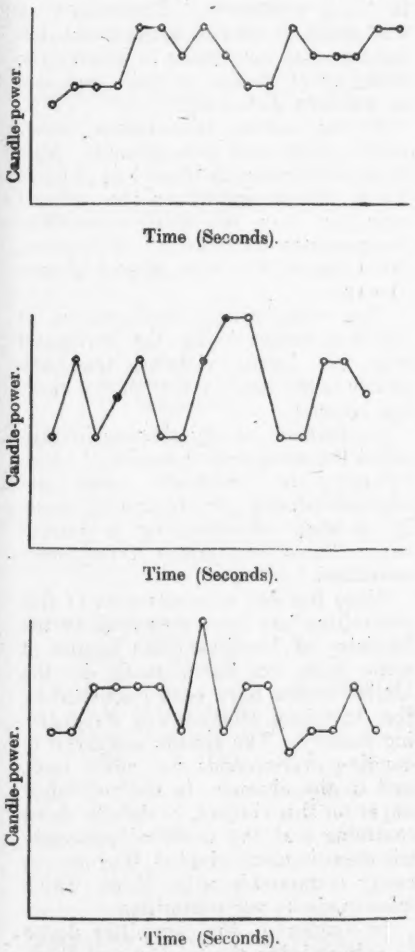



Fig. 3.—Typical Fluctuations in Candle power of Flares. Readings taken every two seconds.

This was essentially a " working committee."

Firework making is no new art. In his preface to " Artificial Fireworks," published in 1766, Lieut. Robert Jones alludes to the age of Augustus and the time of the Trojan War, and observes: " It is sufficient for me that fireworks have subsisted a long time, and still continue to do so among the politest nations of both Europe and Asia."

There already had been " voluminous treatises " on the subject, and these old books, written before strontium and magnesium were discovered, became interesting when there was a serious shortage of such materials.

The firework-maker has no doubt taken care to give as brilliant and beautiful a display as he could, and he provided the Army with the best star-shells and parachute flares that he could make.

When our men fired star-shells away towards the enemy to see what he was doing, the results may have seemed fairly satisfactory until the enemy fired his stars over our trenches. The opinion then was often expressed that his star-shells were more brilliant than ours. An impartial observer with suitable apparatus set up in " no-man's-land " might have investigated the relative values, but it was more convenient to carry out the comparison at experimental grounds in the vicinity of London. It was very gratifying to find that our chemists had no difficulty in making better flares than any that we captured.

Some of the tests consisted of a series of samples all of the same length and diameter but containing progressively different quantities of one of the constituents. What these constituents were does not interest us as photometrists. It might be suggested that there

can be no use in keeping these mixtures secret since hundreds of our flares have been captured and some of them doubtless were analysed. An omelette might be captured and analysed, but even a German chemist might fail to deduce a good recipe for it.

These flares being burned under the same conditions gave photometric results which clearly indicated the result of the differing proportions as they affected candle-power, or rate of burning.

Experiments were made to ascertain the relation between diameter and illuminating value. A series was prepared of flares of progressively increasing diameter, but all of the same length and containing the same mixture. The horizontal candle-power was measured and the diameters, weights, time of burning, candle-power, and candle-power seconds per gramme were plotted as curves. The results were so regular and consistent that good curves were obtained, giving the relations sought. The range was from a ¼-inch flare giving 50 candle-power and 575 candle-power-seconds per gramme to 2¼-inch diameter giving 83,000 candle-power and 6,700 candle-power-seconds per gramme. The efficiency rose rapidly as the diameters increased. The candle-power per gramme rose quickly and attained an almost constant value for all the larger diameters, assuming a constant length.

Having ascertained the most efficient proportions for single flares, nests of three or four were burned in parallel, and useful results were obtained reaching a brilliance of 120,000 to 130,000 candle-power.

Some types of flares are attached to parachutes and dropped from aeroplanes either to enable the flying observers to inspect the ground below, or to give light for others to observe.

In order to confirm by experiment the illumination received on the ground from a flare at a considerable height, a military kite was used, the flare burning at about 34 m. (100 feet) from the ground. The measured illumination agreed closely with the calculated value, and it was easy to deduce the height at which any given type of flare should be burned in order to give an illumination on the ground of 0.005 foot-candle, equivalent to full moonlight.

Other types of "fireworks" known as star-shells are fired from a pistol, bursting into flame at a certain point in their trajectory. Photometry of star-shells so used is not possible, but experiments were made in judging the visibility of groups of men stationed at different distances.

In the earlier experiments, mist, smoke, and wind gave trouble. Mist does not necessarily mean loss of light, for in certain conditions the diffused reflexion from the mist more than compensates for loss by absorption. Moon-less nights were almost always chosen.

The variation in candle-power at different angles below the horizontal was not large, showing that the source is the flame rather than a glowing crater.

Another set of experiments investigated the comparative results of hand-ramming in cardboard cases and machine-pressing in aluminium cases. In another, slow-burning reconnaissance flares of various types were examined.

Since the last interim report of this committee has been presented to the Ministry of Munitions the results of some tests on flares made in the United States have been published by the American Illuminating Engineering Society. The results are given in candle-power-seconds per cubic inch, and in the absence, in the published paper on this subject, of details about ramming and the mode of photometric measurement adopted, they are not easily comparable with those which were made by our committee.

In conclusion, the committee desire to acknowledge the courtesy of those members of the Chemical Warfare Department of the Ministry of Munitions with whom it was such a pleasure to work, and who did everything that was possible to facilitate the experiments and to arrange for the comfort of the working party.

*I.E.S. FLARE & STAR SHELL COMMITTEE.* *Date* 14/12/17. *Observer* J.T.M.

| *Number of Sample* ... ... | $4_a$ | $4_4$ | $4_e$ | $4_5$ | $4_f$ | $4_6$ |
|---|---|---|---|---|---|---|
| *Source and Description of Sample* ... ... ... | Single "A Mixture" | Nest of 3 "A Mixture" | Single "A Mixture" | Nest of 3 "A Mixture" | Single "A Mixture" | Nest of 3 "A Mixture" |
| *Weight of Sample (gm.)* ... | 57·5 | 172 | 57·5 | 172 | 57·5 | 172 |
| *Dimensions of Sample* ... | 3" long 1" diam. | 3" long 1" diam. | 3" long 1" diam. | 3" long 1" diam. | 3" long 1" diam. | 3" long 1" diam. |
| *Burning time (secs.)* ... | 23 | 22 | 24·5 | 21·5 | 21 | 22 |
| *Distance from Photr. (ft.)* ... | 70 | 70 | 70 | 70 | 70 | 70 |

| | *L* | *F* | *L* | *F* | *L* | *F* | *L* | *F* | *L* | *F* | *L* | *F* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Photometer Readings* L—*Letters* F—*Foot-candles* | L | 1·7 | H | 5·8 | M | 1·31 | G | 8·45 | L | 1·7 | G | 8·45 |
| | L | 1·7 | H | 5·8 | L | 1·7 | G | 8·45 | K | 2·22 | H | 5·8 |
| *Mean Times of Burning:—* *(Seconds)* | L | 1·7 | G | 8·45 | L | 1·7 | H | 5·8 | J | 2·76 | H | 5·8 |
| Single 23 | J | 2·76 | G | 8·45 | L | 1·7 | G | 8·45 | J | 2·76 | H | 5·8 |
| 24·5 | K | 2·22 | G | 8·45 | K | 2·22 | G | 8·45 | J | 2·76 | H | 5·8 |
| 21 | J | 2·76 | H | 5·8 | K | 2·22 | H | 5·8 | N | 0·99 | G | 8·45 |
| 3\|68·5 | J | 2·76 | H | 5·8 | L | 1·7 | G | 8·45 | | | H | 5·8 |
| 22·9 | K | 2·22 | H | 5·8 | | | G | 8·45 | | | G | 8·45 |
| Nest 22 | K | 2·22 | H | 5·8 | | | I | 3·9 | | | H | 5·8 |
| 21·5 | | | O | 0·77 | | | | | | | | |
| 22 | | | | | | | | | | | | |
| 3\|65·5 | | | | | | | | | | | | |
| 21·8 | | | | | | | | | | | | |
| *Mean Illumination:—* *(Foot-candles)* | | | | | | | | | | | | |
| Single 2·23 | | | | | | | | | | | | |
| 1·8 | | | | | | | | | | | | |
| 2·2 | | | | | | | | | | | | |
| 3\|6·23 | | | | | | | | | | | | |
| 2·08 | | | | | | | | | | | | |
| Nest 6·09 | | | | | | | | | | | | |
| 2·35 | | | | | | | | | | | | |
| 6·68 | | | | | | | | | | | | |
| 3\|20·12 | | | | | | | | | | | | |
| 6·7 | | | | | | | | | | | | |
| *Total* ... ... ... ... | 9 | 20·04 | 10 | 60·92 | 7 | 12·55 | 9 | 66·20 | 6 | 13·19 | 9 | 60·15 |
| *Mean Illumination* ... | | 2·23 | | 6·09 | | 1·8 | | 7·35 | | 2·2 | | 6·68 |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Candle-power (Mean)* ... | Single ... | 10,200 | Nest ... | 29,700 | Ratio ... | 2·91 |
| *C.P., Seconds (Mean)* ... | Single ... | 235,000 | Single ... | 660,000 | | |
| *C.P., Secs. per Gm. (Mean)* | Nest ... | 4,050 | Nest ... | 3,850 | Ratio ... | 0·95 |

**Typical Observation Sheet Used for Experiments on Flares.**

# SOME PHOTOMETRIC TESTS OF THE BRIGHTNESS OF RADIO-ACTIVE SELF-LUMINOUS MATERIALS.

BY W. C. CLINTON.

(Presented at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 8 p.m., on Thursday, December 19th, 1918.

In a discussion before this Society in March, 1917, some account was given of the properties of self-luminous radio-active paint, a material which has found many special uses during the war. Mr. A. Blok then explained some of the photometric difficulties experienced in measuring the brightness of such substances, arising from their feeble luminosity and peculiar colour.* Messrs. C. C. Paterson, J. W. T. Walsh and W. F. Higgins have also given a detailed account of work on this subject carried out at the National Physical Laboratory.†

A series of tests on such substances was commenced by a committee of the Illuminating Engineering Society (consisting of Messrs. A. Blok, W. C. Clinton, J. S. Dow and L. Gaster (Chairman) in the autumn of 1916, and a complete report of these researches has been furnished to the Ministry of Munitions and has also been placed at the services of the Government Departments interested in other Allied countries. As soon as this complete information can be released it will be accessible to members of this Society who are interested. Meantime, permission has been accorded by the Ministry of Munitions for some account of the tests and apparatus employed to be given at the opening meeting of the present session. The data now presented are the result of tests extending over more than a year. In view of the novelty of the problem, it was decided that tests should be made in duplicate by two observers (Messrs. Dow and Clinton); able assistance was also rendered by Miss Ladler, of the Ministry of Munitions.

In both cases the method was substantially that referred to by Mr. Blok —namely, the viewing of the luminous sample through a very small slit in a white surface illuminated by a glow-lamp which was maintained at a fixed P.D. and screened by a suitable green glass filter. In this way relative results were easily obtained. They were made absolute with fair accuracy by a determination of the absorption of the green filter. As the samples consisted of small tubes, it was found convenient to mount them on drums which could be rotated behind the illuminated slit so as to bring any desired sample immediately behind it. In my own experiments the test was made upon a photometric bench, the white screen with the drum behind it being mounted on a carriage and substituted for the Lummer Brodhun photometer ordinarily used. In Mr. Dow's experiments a small photometer box, also operating on the inverse square law, but using a small glow-lamp fed by an accumulator, was employed.

The white screen used was made by precipitating barium sulphate on a sheet of microscope cover glass. The aperture was made by scraping away the barium sulphate over a small rectangle 2.5 mm. high by 0.4 mm. wide. This gave a very fine line of division; but, owing to the small size of the slit, it was found desirable to view it through the magnifying eye-piece telescope taken from a Lummer Brodhun photometer. With a view to avoiding direct reflection we both found it expedient

* *Illuminating Engineer*, March, 1917, p. 76.

† Paper presented before the Physical Society, May 25th, 1917.

to adopt an angle of inclination somewhat less than 45 degrees; in my case, about 35 degrees.

The chief object of the investigation was to determine the rate of decay in brightness of samples having varying percentages of radium bromide—0.1, 0.2, 0.3, 0.4, 0.5, and 0.8 mg. of radium bromide per gramme of zinc sulphide. Considering the photometric difficulties, the results obtained by both observers were in very fair agreement. The data obtained may be briefly summarised, thus:

| Radium Bromide Content in mg/gm. | Max. Brightness. Brightness after 300 days. | | Brightness after 300 days expressed as percentage of brightness of 0.8 mg/gm compound | |
|---|---|---|---|---|
| | A | B | A | B |
| 0.8 | 6.6 | 7.1 | 100 | 100 |
| 0.5 | 4.2 | 4.2 | 98 | 100 |
| 0.4 | 3.6 | 3.45 | 92 | 100 |
| 0.3 | 3.0 | 2.9 | 85 | 94 |
| 0.2 | 2.35 | 2.35 | 77 | 80 |
| 0.1 | 1.7 | 1.6 | 59 | 68 |

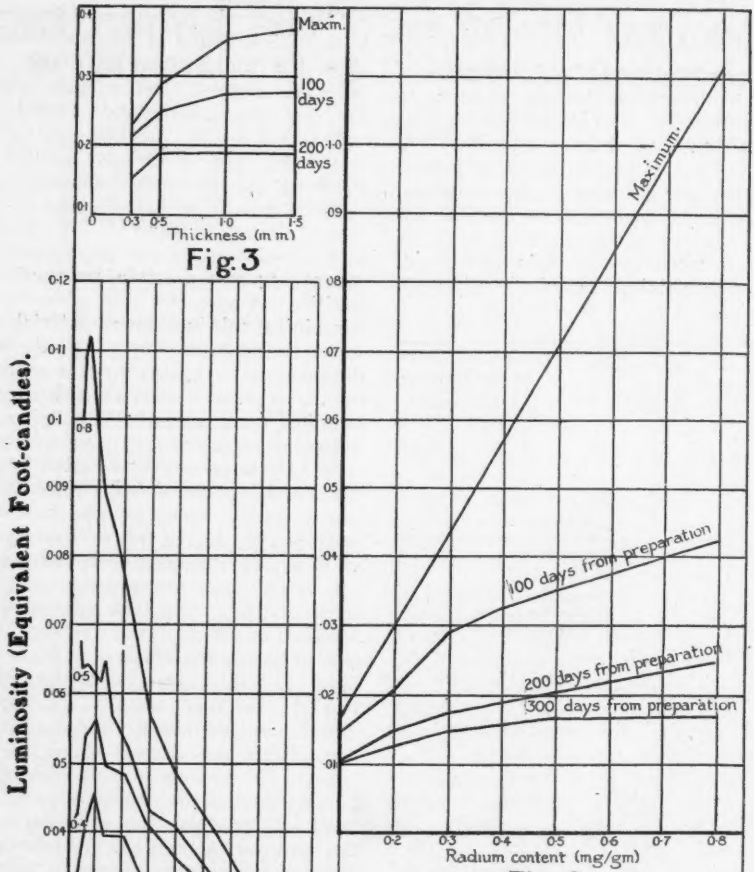
A Clinton and Miss Ladler.
B Dow.

In Fig. 1 I am presenting, as typical, the decay curves obtained by myself and Miss Ladler over a period of 300 days. The brightness, as the ordinate, is expressed in terms of "equivalent foot-candles," the period in days being represented as the abscissa.

The curves show what has been found by other observers—a short initial rise follows by a steady, but gradually diminishing fall, so that towards the end of the period the difference between the brightness of the various samples is very much less than at the commencement. The maximum brightness values at the peak of the curve, for freshly prepared material, are roughly proportional to the radium content, and numerically about one-tenth of the strength of composition in milligrammes per gramme. All these samples were tested in the form of powder. As is well known, the admixture of varnish necessary for their use in the form of paint is equivalent to dilution; the initial brightness is proportionally reduced, but the rate of decay also takes place more slowly.

From these tests it would appear that if such materials are to be in use for long periods there is no advantage in using compound of greater strength than 0.2 mg./gm., while later experiences suggest that in many cases 0.1 mg./gm. compound (which is understood to be roughly equivalent to 0.4 mg./gm. compound applied in the form of paint) would answer.

There were other experiences in our test which are of interest. We found, at an early stage, the importance of preventing any possible entry of impurities through the seal of a vessel containing self-luminous material, by which the brightness may be materially diminished. We also made a number of tests on collections of tubes of identical composition. Although individual differences were encountered, such variations rarely exceeded 20 per cent. and in general fell within 10 per cent., which must be considered a satisfactory degree of uniformity in view of the various circumstances on which the initial brightness of such tubes depends. Another point of some interest in photometric tests of this description is the effect of exposure to light. In this case it was desired to test the samples, so far as possible, under actual working conditions, and accordingly the drums on which the tubes were mounted were kept in glass boxes standing on the window-sill of the laboratory and thus exposed to full daylight during the day. I understand that such exposure tends to impede the darkening of the glass due to radium emanations, so that the diminution in brightness with time might possibly be somewhat greater in the case of tubes always kept in darkness. In order to avoid any confusion through extra phosphorescence of the zinc sulphide after exposure to daylight, we made it our practice invariably to remove the tubes into complete darkness for two hours before tests were made. The possibility of exciting phosphorescence by exposure to artificial light in handling the tubes was also considered. So far as artificial light from incandescent (electric) lamps is concerned, it appeared that no appreciable effect on the luminosity would




**Luminosity Curves for Samples of Radium Content (mg./gm.).**

Figs. 1 and 2 show diminution in luminosity with time.
Fig. 3 shows effect of depth of material (0.3 mg./gm. composition).

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be produced by such illuminations as commonly prevail in artificially lighted interiors. On the other hand, a marked temporary increase in luminosity could be produced by exposure to full daylight, which, however, did not last more than about 25 minutes.

A point of interest which does not appear to have been discussed elsewhere is the effect of depth of material. In order to test this the author constructed four cells respectively 0.3, 0.5, 1.0 and 1.5 millimetres in thickness, the width being 2.6 mm. and the length of parallel slot from 10-12 mm. In these tests 0.3 mg./gm. composition was used. Observations were made on these cells in the same manner as on the small tubes previously mentioned, and the results are summarised in Fig. 3. At the beginning of the test the cell 0.3 mm. thick had a brightness of 63 per cent. of that of the cell 1.5 mm. thick, and after 200 days this ratio had become 82 per cent. This would indicate that a greater thickness than 0.3 mm. is not necessary for 0.3 mg./gm. compound, and as this material is not much better than 0.2 mg./gm. compound when aged, a thickness of 0.3 mm. appears sufficient. This depth was, however, exceeded in the tubes referred to above. It is very interesting to observe that an increase in thickness besides increasing, up to a certain point, the initial brightness, also tends to accelerate the decay of luminosity. In short, the effect seems to be similar to that of increasing the percentage of radium bromide in the composition.

Obviously the choice both of composition of material and of thickness used is of considerable importance in view of the high cost of radium. The determination of the minimum percentage of radium bromide and minimum thickness necessary to obtain efficient results has resulted in a considerable reduction of expenditure on those war munitions in which this material has been used. The many special uses to which such radium compound has been put since the war cannot at present be discussed in detail. In the near future they will doubtless find many novel applications and peaceful uses; but here, too, the selection of the conditions giving the requisite luminosity for each problem and yet involving the minimum use of material will require careful study.

*(The complete discussion of the above two papers will appear in our next issue.*—ED.)

# REVIEWS OF BOOKS

## AND PUBLICATIONS RECEIVED.

*A Statistical Report of Electrical Undertakings in Japan. (Issued by the Director-General of Electric Exploitations, Tokyo, Japan, May, 1918.)*

THE report consists of a summary of statistics showing the condition of electric undertakings in Japan at the end of 1916 (except in Formosa, Corea, Saghalin and Kwantung). It is divided into eight sections, dealing respectively with:—Number of Undertakings, Kilowatt Capacity, Number of Generating Stations, Length of Electric Lines and Number of Supports, Length of Tracks and Number of Cars, Electric Lamps and Motors Wired, Tariff of Electric Light and Power Capital, Revenues and Expenditures.

The data is presented in a very convenient and compact form, occupying only 20 pages. In Part I. the existing undertakings are classified in various ways, *e.g.*, by cities, according to pressure and nature of supply, etc. Part II., which deals with similar information by date (1903—1916), is of special interest as showing the striking progress made in Japan over this period. Thus the number of undertakings has risen from 81 in 1903 to 472 in 1916, the kilowatt capacity in the same period from 44,252 to 805,289, and the number of lamps (10 c.p.) from 365,090 to 9,975,554. Of special interest, also, is the very comprehensive series of data for fifteen of the chief cities in Japan, covering the number of households and consumers and the population; number of lamps and total candlepower; and the average numbers of lamps and candlepower per consumer, per household, and per hundred of population.

We cannot recall having seen any similar full data for cities in the British Isles, and the comparison drawn between different cities is most instructive. Thus we find that Osaka has the highest candlepower per hundred of population (1,087), but in number of lamps per hundred of population it is far from being at the head of the list, the figure being 49·8, whereas Tokyo comes first with 78·6. It would appear, therefore, that lamps of higher candlepower are more habitually used in Osaka than in Tokyo—a difference which could no doubt be explained by considering the different industrial conditions prevailing in the two cities. This schedule enables many other interesting comparisons to be drawn and we commend the report to British readers.

*The Properties of and Testing of Optical Instruments. (Circular No. 27, issued by the Bureau of Standards, Washington.)*

THOSE concerned with optical instruments, which have played a great part during the war, should study this publication of the Bureau of Standards, in which the salient features of the more common optical instruments, and relatively simple methods of testing their requirements, are given. The treatment covers definition, magnification, brightness of image, field of view, stereoscopic vision, faults of lenses and methods of correcting them.

*Spectro-radiometric Investigations of the Transmission of Various Substances. (Scientific Paper No. 325, issued by the Bureau of Standards, Washington.)*

AMONG the substances studied in this investigation may be mentioned fluorite and coloured glasses. The data are chiefly of interest as an indication of methods of obtaining narrow spectrum bands of energy of high intensity and large areas without the use of a spectroscope. Some of the data have also a useful bearing on the provision of materials to screen the eye from injurious forms of radiation.

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# EDITORIAL.

## Good Lighting as an Essential Element in Public Health.

At the end of this eventful year, during which we have seen the final triumph of the Allied cause, the cessation of hostilities, and the arrival of the period of reconstruction, it is well to review some of the tendencies developed during the last four years, and to consider how we can best benefit by making permanent use of some of the lessons of the war.

In connection with lighting, the public has submitted to many restrictions rendered inevitable by the national demands. Economy in many directions has been necessary, and control has been exercised in order to secure uniformity of procedure. At the same time events have demonstrated, even more forcibly than before the war, the vital importance of good industrial lighting. It has played an important part everywhere in stimulating production; in preventing visual, mental and physical fatigue; in securing safety to persons and property and saving life, time and materials. These facts are recalled in a timely article in the *Electrical Review and Western Electrician*, wherein attention is drawn to the alertness with which Europe is applying the lessons of the war in the field of illumination. In the United States, too, considerable progress towards national encouragement of better lighting has been made. Four States—New Jersey, Wisconsin, Pennsylvania and New York—have adopted some form of legislation

dealing with the lighting of factories, while a fifth State—Ohio—possesses tentative laws based largely on the advice of the Illuminating Engineering Society in the United States.

In this country the Home Office took a most important and enterprising step in the appointment, previous to the war, of the Home Office Departmental Committee on Lighting in Factories and Workshops, whose Interim Report was issued in 1915. The moment is now ripe for the extension of this work to a further stage, leading to the ultimate recognition of good lighting in factories as of equal importance to proper ventilation, heating and sanitary measures. During the past ten years the value of good lighting has been brought home alike to employers and employees. Experience has shown that wherever an improvement in lighting has been made neither management nor staff desire to return to the old conditions. The evidence of the effect of improved lighting on health, safety and efficiency of work is now so strong that the workers will make unmistakable demands on this point.

The provision of proper conditions for work, including the hours of labour and the environment in which the operations proceed, is rapidly passing from a national to an international problem. One of the most striking illustrations of this is the announcement that these problems will be the subject of joint study by the nations represented at the Peace Conference. We trust that among the other questions considered the importance of good lighting will receive full consideration.

That there should be uniform action in regard to lighting, and measures to secure that satisfactory conditions of illumination are general, is self-evident. We feel sure, also, now that the benefits of good illumination are better appreciated, there will be no serious opposition to measures of such obvious public benefit. In many directions the public has acquiesced in measures for its protection and welfare. Promiscuous expectoration, the carrying of firearms, too rapid or careless driving of vehicles and similar practices injurious to health and safety, are forbidden. Why, it is asked, should not illumination, such a powerful factor for good or harm, also be the subject of intelligent control?

We have referred especially to industrial lighting, but there are many other fields where there is a similar need for action. In schools proper lighting is recognised as essential to the health and vision of children, in streets it is similarly a vital factor to safety and convenience, and on railways, wharfs, dockyards, etc., it is of great importance both in relation to safety and rapid execution of work. We have now arrived at a stage when the main principles of good illumination are understood. In each case there are other special points, according to the nature of the work done or the function which the light has to fulfil, which may require further consideration. All such points could be most conveniently settled by conference between lighting experts and those associated with the use of the illumination; the conditions should be settled for each industry by consultation in the same manner as problems are now being decided by the joint industrial councils. In many cases the data already obtained by the Illuminating Engineering Society, and presented in papers and discussions, would afford a good basis on which to build.

The essential point is that all such regulations affecting lighting should be settled by *consent*, and we may then be sure that all concerned will unite in loyally carrying them out for the common benefit

## Statistics of Electric Lighting.

While very full statistical data are presented each year on many general points in connection with the electric and gas industries we have often remarked that there seem to be many gaps to be filled in regard to progress in illumination. Conditions during the war have, for example, directed public attention to the manufacture of electric incandescent lamps in this country, but although a general idea existed as to the number of lamps this country required per annum, there were few detailed statistics on the subject, and there is still less information available to the public regarding the conditions that have prevailed during the war. It would be of great interest to have an authoritative survey of the electric lamp situation in this country, covering the number of lamps of various kinds made and required, and especially the practice ruling in different cities.

We are led to refer to this subject by an interesting statistical report on electrical undertakings in Japan, a review of which appeared in our last issue.* The Report contains general data on the development of electric undertakings, miles of electric railway track, etc., during each year from 1903 to 1916. But the data which concern us chiefly are those relating to electric lamps. It is evident that very great progress is being made in Japan. The number of lamps in use (10 candlepower) has increased from 457,361 in 1903 to 10,790,776 in 1916 and the rate of increase from 1915 to 1916 was 18 per cent. Developments since that year are believed to have been equally rapid. Some striking data are presented for fifteen of the chief cities in Japan, the number of consumers, total candlepower, and the number of lamps and candlepower per hundred of population being presented in each case. What is particularly to be noted is that the city which comes out highest in number of lamps per hundred people does not necessarily use the greatest candlepower per head. Thus Tokyo heads the list with 78·6 lamps per 100 population, but has only 656 candlepower per hundred persons, while Osaka, with a much lower number of lamps, has 1,087 candlepower per hundred of population. No doubt this and other anomalies could be explained by a full knowledge of the industrial conditions in each city, the nature of the street lighting and other factors. It must be, however, most useful to the companies concerned to have such a comparison, since it indicates roughly those cities which seem to lag behind the others and require stimulation.

We have no doubt that a certain amount of information on the subject has been accumulated by electric supply companies and others. While few data have been publicly presented on the matter, we understand that, broadly speaking, there is reason to think that the amount of electric light used per person in this country is less than the values prevailing in the United States and some Continental countries. Before drawing conclusions on this point it would be necessary to have full data regarding the amount of light used in the form of other illuminants, but the point is one which, in the interests both of the public and the lighting industry as a whole, it would be very desirable to investigate.

* ILLUM. ENG., Nov., 1918, p. 264.

## Problems in Photometry.

In our last issue we commented on the interesting papers presented by the President and Mr. W. C. Clinton at the Meeting of the Illuminating Engineering Society, on December 19th, dealing respectively with the photometry of flares and parachute lights, and self-luminous radio-active materials. In this number we give a summary of the subsequent discussion, in which several other interesting points in photometry were also raised (see pp. 269—276).

Much of the discussion naturally related to the special researches referred to above, the new photometrical apparatus designed for their solution and the applicability of such apparatus to photometry generally. In particular it was suggested that the form of photometer used for the flare-tests, which could be read by simple inspection, would have a useful field for demonstration purposes, while in the future it is conceivable that instruments for approximate work might be devised, using luminous paint as a comparison-surface and obviating the need for a glow lamp and battery. One great difficulty in the latter class of appliances, however, is the question of finding a suitable means of diminishing the incident light (as the brightness of the surface within the instrument cannot conveniently be varied). This problem recurs in many optical researches and is well worth the attention of the Society.

Some interesting suggestions were made by Mr. C. C. Paterson regarding the testing of gas-filled incandescent electric lamps. The difference in colour between the light of these sources and vacuum lamps presents difficulties which can, however, be overcome by various expedients. A more serious difficulty, which invalidates to some extent the ordinary specification tests, is the fact that with gas-filled lamps " watts per candle " do not necessarily furnish an indication of temperature of incandescence and consequent life and are also tedious to determine in practice. Mr. Paterson suggested a method of avoiding this trouble in future specifications which deserves to be the subject of further experiment.

What, however, we regard as one of the most important points raised in the discussion is the use of the cubical integrating photometer for measuring total flux of light. Some months ago we referred to this problem, which has assumed great importance in view of the varied distribution of light from modern illuminants.* The Globe photometer, though possessing many theoretical advantages, is inconvenient to construct and a cubical form would be preferable in practice, if sufficiently accurate. Mr. J. W. T. Walsh described some encouraging experience with this form of apparatus at the National Physical Laboratory, and we hope that other members will take the matter up so that the possibilities and limitations of the device may be more fully understood. A question of considerable importance is the application of such devices to gas lamps, which require adequate access of air for purposes of combustion, and may suffer in candlepower if confined within a closed apparatus. From this standpoint a method which has lately been the subject of experiment in the United States, involving the use of an open hemisphere, deserves attention. If sufficiently accurate results could be obtained with a " half-cube," an important step would have been taken towards the solution of the problem of integrating the flux of light from gas units as well as electric lamps.

LEON GASTER.

* ILLUM. ENG., Aug., 1918, p. 188.

TRANSACTIONS

OF

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*The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.*

# PROGRESS IN PHOTOMETRY WITH SPECIAL REFERENCE TO WAR PROBLEMS.

## (Tests of Parachute Lights and Flares, Self-Luminous Radio-active Paint, Integrating Photometers, etc.)

### *DISCUSSION.*

(Summary of Discussion at the first meeting of the Session, held at the House of the Roy. l Society of Arts, 18, John Street, Adelphi, London, W., at 8 p.m., on Thursday, December 19th, 1918.

(*Continued from p.* 263 *in* THE ILLUMINATING ENGINEER *for November*, 1918.)

Mr. J. S. Dow, in opening the discussion, remarked that the type of photometer described by Mr. Trotter represented a new development in photometry, as it could be observed by a number of people simultaneously from a distance. It should therefore be valuable for demonstration purposes. Thus if the scale were calibrated, direct in foot-candles, one could readily use the instrument to demonstrate the value of reflectors. One could, for example, note the point of balance when the scale was illuminated by a bare lamp, and then the improvement in illumination when the lamp was enclosed in a suitable reflector. The apparatus could, however, also be made in a small portable form, and he showed a pocket apparatus which was operated on the same principle, but was only about 10 inches long and 1½ inches wide and deep.

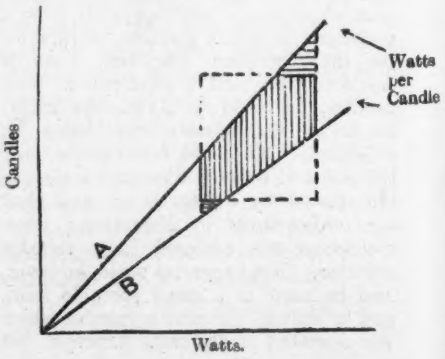
In the past the general view had been that a regulating resistance and voltmeter was not essential for the ordinary illumination photometer. He was inclined to think now, however, that for accurate instruments a battery of greater capacity than was commonly used, and a really adequate resistance and voltmeter or ammeter would be an advantage. It was, however, essential that this apparatus should be exceptionally reliable. On the other hand, he had been wondering whether, for approximate work, one could not devise a method which did not involve the use of a lamp and battery. It might be possible to get a rough idea of illumination by some device based on acuteness of vision, not in regard to

form, but in regard to sensibility to contrast, which he thought was a more reliable factor and less subject to personal variation. Naturally such instruments would not be as accurate as those using a lamp and battery, and might more properly be described as "illumination-gauges."

Apparatus based on acuteness of vision had several limitations. One could only ascertain at what illumination a pattern could no longer be distinguished—there was no point of reversal. This had led him to consider whether a small patch of self-luminous radio-active material could not be used as the comparison source. Its brightness would remain sensibly constant over a long period of time, if the material had been properly aged, and the apparatus would require checking only at relatively long intervals, perhaps every few months. He had made an experimental form of apparatus of this kind, which he exhibited, intended primarily for tests of phosphorescent phenomena. By inserting a green glass in the path of rays from the surface studied it could possibly be used for rough tests on illumination from ordinary sources. The chief difficulties were the very low luminosity at which tests had to be made and the possible interference of the Purkinje effect. The photometric screen in this case was a patch of self-luminous paint on glass, with a slit scraped away in the centre through which the surface studied was viewed (thus reversing the method used in the photometer described by Mr. Clinton). Photometric balance had to be made by dimming the light from the exterior surface. There was no really satisfactory way of doing this, but he had used a wedge of graded absorption. This admittedly was not a really satisfactory method, and he would be glad to hear of any means by which incident light could be weakened according to a straight line law. He would also like to inquire if there was any known physical means by which the brightness of a surface could be increased without the addition of more light from an extraneous source. If, for example, one could focus the light from the self-luminous surface by a plano-convex lens and thus obtain a greater brightness, it would assist the design of photometers of this class. But he doubted whether this could be done.

Mr. C. C. PATERSON spoke upon a few matters in which the National Physical Laboratory had been doing work in connection with the subjects under discussion. The first was the question of a satisfactory specification for the acceptance of electric lamps. The ordinary diagram upon which acceptance was based introduced difficulties when applied to gas-filled lamps. Gas-filled photometric standards were not satisfactory, and the very large colour difference when ordinary substandards were used inevitably introduced errors and uncertainties in measurements of candlepower. There was also the difficulty with gas-filled lamps that the watts per candle were not a rigid criterion of the temperature of the filaments, because watts per candle varied according to the pressure and nature of the gas inside the lamp.

There was also another serious practical drawback to the existing method of specification. Specifications fixed limits for three quantities—candles, watts, and watts per candle. The candles and the watts were measured in practice, and the lamps outside the limits were rejected. It was usually, however, too laborious to divide the watts taken by each lamp by its candles, with the result that the watts per candle limits were seldom applied in practice. The effect of this is shown in the diagram.



Instead of only accepting lamps which fall within the vertically shaded area, all lamps would be passed which fall within the rectangle, and obviously some very low efficiency lamps and some which were too high would then be passed.

In view of the various difficulties they had proposed a way of specifying acceptance tests for gas-filled and other lamps, which had been already embodied, with the manufacturers' support, in one or two specifications.

It is not always realised how exactly equal is the filament temperature of vacuum lamps which lie anywhere on one of the diagonal " watts per candle " lines in the above diagram. In other words the watts per average candle of a vacuum lamp are a very close criterion of the filament temperature. It is the desirability of obtaining uniformity in filament temperature which has always underlain the specification of limits for watts per candle. Uniformity of filament temperature is one of the chief factors in obtaining a uniform life performance of incandescent lamps, and for a similar reason we desire uniformity in the filament temperature of gas-filled lamps. As is now well known,* filament temperatures can be gauged by the photometric method of colour identity. A vacuum tungsten filament lamp running at known watts per average candle can be used in this method as a pyrometer. For instance, we can have one such lamp adjusted to lie on line A on the diagram, and another on line B. By comparing the light from the test lamp against that from each standard in turn it is relatively easy to see whether it falls between the filament temperature limits represented by lamps A and B. The proposal, therefore, is to specify only limits for watts and filament temperature, thus leaving the candlepower to follow automatically. Although the theoretical limits of resulting candlepower are extended by this, in practice the extension will not be found serious, because, as seen in the diagram, only a small unimportant triangular area is added to the top and bottom of the diagram respectively. (This area is shaded horizontally.)

There was one obvious difficulty in that a vacuum lamp could not be run at the same temperature as a gas lamp without damaging it, but this difficulty is got over by placing a suitable Wratten colour filter in front of the lamp so that the pyrometer lamp does not have to run at the same filament temperature as the lamp under test. He felt sure that all who had been familiar with the difficulties that had occurred in the past in the practical testing of the candlepower of large numbers of lamps would treat sympathetically any suggestion which might possibly eliminate sources of trouble and dispute.

Captain G. GRAY (Chemical Warfare Dept., M.O.M.) said that great credit was due to the Society for the work conducted for the Ministry by its committees. In comparing various flashlight compositions it had been most valuable to have available methods of photometric measurements, which could be applied in the open, and from the service point of view much of the work carried out on flares was most interesting. What was necessary in the field was to detect the movements of the enemy, what the Committee had aimed at was a precise method of measuring illuminating value. The combined application of photometric measurements and tests on the revealing power of flares in practice had enabled them to arrive at some definite and useful conclusions. In this connection he would like to refer to some supplementary tests which were undertaken in order to correct an impression that in the design of flares this country was behind the enemy. A comprehensive series of comparisons were made between British and German cartridges. The President, in his paper, had pointed out how different the effect of a cartridge appeared according as it was fired towards the observer or fired away from him. In the trial referred to, the cartridges were first fired away from the observers, who were asked to take note whether they thought each cartridge was German or British. Then cartridges were fired towards the observers and similar notes taken. A number of officers of high standing were present, and the unanimous conclusion was that the British cartridges were the better.

* Paterson and Dudding, Proc. Phys. Soc.

Some reference has been made to the use of coloured lights, a field of work in which further investigation was well worth while. During the war they had found only two colours satisfactory as a supplement to white—namely, green and red. Yellow light was poor from the standpoint of discrimination between signals, and blue very bad. They had always found in signalling that the nearer they could get to a true signal-green the better the results. As S.O.S. signals in Service they used a chain of three lights, which were invariably composed of some combination of red and green. They found that if red and green were used the visibility was greatly improved as compared with other colours —a result which was apparently due to the smaller amount of halation. The general tendency to halation was again decreased as they approached signal-green, but the imitation of this colour was a somewhat complex chemical problem. Undoubtedly a great deal remained to be done in determining the relation between colour, visibility and halation.

Mr. F. F. S. BRYSON, speaking on behalf of the Optical Branch of the Ministry of Munitions, said that he wished to convey to the Society an expression of thanks from the Ministry for the valuable work that had been carried out by the two Committees—work that had called for a considerable amount of energy and initiative. The practical value of the tests on the brightness of radio-active materials was obvious. The tests had served to determine the diminution in brightness within a given period of samples containing varying proportions of radium bromide. As a considerable time often elapsed between the date at which instruments were made and the date on which they were put into service the behaviour of the self-luminous compound on them in the later stages of their life was of great importance. One result of the investigation had been that the amount of radium bromide in certain instruments had been reduced from 0·4 mg./gm. to 0·2 mg./gm, and this naturally meant a very considerable saving in valuable material. The results of the investigation on the effect of amount of material had also been most useful and would undoubtedly prove a useful guide in the application of these substances to the purposes of peace.

Mr. F. HARRISON GLEW said that one thing which the work done at the National Physical Laboratory and by the Committee had demonstrated to the higher authorities was that the brightest effects were not really necessary. The difficulty mentioned by Mr. Clinton of having to leave the test subject in darkness for a certain number of hours could be got over. It was not always practicable to do this, nor was it really necessary, because by having a red lamp or a red glass it was quite possible to wipe out all phosphorescence in a few seconds. The curves which had been shown of initial rise of illumination were exactly, or nearly what would be expected, but there was a fluctuating brightness always possible when dealing with a surface which was not painted but of a powdery or crystallised nature, with interspaces between the crystals. There was free play for the circulation of emanations, and there was a possibility of fluctuating brightness from time to time. That effect was noticeable when dealing with a bank of tubes, say 300 or 400. The brightness of individual tubes varied from time to time, and that was largely due to the actual circulation of the emanation in the tubes. That effect could best be studied in a large tube where it was possible to have a patch of four times the luminosity in one part of the tube to another part. There were ways of diminishing that but not altogether overcoming it, but recent improvements in the manufacture of radium compound would very largely diminish the possibility of this kind of fluctuation.

Mr. J. W. T. WALSH referred to one or two problems which had been dealt with at the National Physical Laboratory during the past four years.

The first was the use of an integrating photometer, which should, theoretically, be a sphere, but owing to various reasons had actually been made in the form of a cube. The theoretical disadvantages in the use of a whitened cube as compared with a sphere were, of course, many, but it had,

for some purposes, distinct advantages from the practical point of view. The purpose for which it had been used at the National Physical Laboratory was the investigation of the candlepower of large carbon arcs. These arcs were burned in a somewhat bulky framework, and the practicability of erecting the framework with its various auxiliary apparatus in a cube greatly exceeded what he imagined it would be in a sphere. The main objection to the use of a cube was that in the case of a source of non-uniform distribution the result would differ according to the direction in which the light was directed. That error might reach something of the order of 10 or 15 per cent. in the case of a very non-uniform source, but actually if care were taken that the source always had the same orientation, and if it were compared with a known source of approximately the same distribution, it was possible to obtain fairly accurate measurements.

For this purpose it had been found that a large metal filament lamp with a shade of hemispherical shape behind it gave a polar curve almost identical with that of the ordinary carbon arc, except, of course, at the central point. In that way it had been possible to determine the total candlepower from the arc by a single measurement in a cubical photometer.

They had met various other difficulties during the course of the experiments, particularly that due to the ageing of the interior surface. Ageing was very much more rapid where the surface was exposed to the intense ultra-violet light which was given by the arc. There was also a certain quantity of fume in the case of many carbons, so that it had been necessary to repaint the interior of the cube at repeated intervals.

With regard to Mr. Clinton's paper, it was very interesting indeed to find that the actual luminosity values obtained were so close to those given in the paper by himself and others before the Physical Society to which Mr. Clinton had referred. At the same time, the samples upon which Mr. Clinton worked were obtained two years ago, and vast improvements had been made in the quality of compound since then which had had the effect of more than doubling the luminosity shown on the curves. Judging by these curves, it appeared that the peak values of the compounds were not strictly in proportion to the radium content of the compound. The peak value, for instance, of the 0·2 mg./gm. compound appeared to be less than half that of the 0·4 mg./gm. compound. That seemed to be in disagreement with their experience at the National Physical Laboratory, where it had been found that the initial value, when the compound was freshly made, was strictly in proportion to the radium content. With lapse of time, of course, the stronger compound approximated more and more closely to the weaker, so that one would have expected rather that the luminosity of the 0·02 mg./gm. material would have been greater, and not less, than half that of the 0·4. He would like to ask Mr. Clinton whether he had found any difficulty due to light reflections from the back of the white comparison surface which he used. At the National Physical Laboratory, until they blackened the back of the white surface they were troubled with reflections from the luminous paint.

He was particularly interested in the remarks of Mr. Clinton and Mr. Glew as to the effect of keeping tubes in daylight. Tests at the National Physical Laboratory were made entirely on tubes kept in the dark for the whole of their life, so that the glass had become discoloured. Allowance, however, had been made for that, so that the results were strictly comparable with those of Mr. Clinton. It was interesting, seeing that very few tests had been made on the effect of exposure to daylight on the capacity of zinc sulphide to respond to radium excitation that such curves as had been obtained followed closely the same kind of law as that of a compound which was kept continuously in the dark.

He would like to ask Mr. Clinton whether he had any theoretical explanation of the fact that increasing the thickness of the compound increased the rate of decay. He could not himself think of any possible explanation, but it was a very interesting fact, and one that deserved further investigation.

Mr. ARTHUR BLOK said that as a Member of the Government Department

for which the work had been undertaken by the Society, he could not add much to the papers in respect of radium measurements without disclosing matters of official secrecy. In connection with Mr. Walsh's very interesting remarks on the cubical integrator, he understood him to say that he had experienced trouble with the ageing of the surface, by which he understood him to mean the deterioration of the colour. Did that make any difference? He should have thought that one of the chief attractions of the cubical integrator was that so long as it was calibrated with a known lamp immediately before making the measurement, the internal condition did not enter into the validity of the result. The cubical integrator had always attracted him from the point of view of what he might call rough commercial sale-room photometry, and he very much wished that some enterprising firm engaged in pushing shades, reflectors and the like would develop a simple form of cubical integrator which could be given to sales merchants for the purpose of public education in the purchase of fittings. At the present moment everybody interested in good lighting, and electrical people in particular, were engaged in a lumen campaign in order to educate the public up to the fact that in buying a lamp or a lighting unit consisting of lamp and shade it is purchasing light and not candlepower, and from this point of view there was room for a salesmanship campaign in which some simple device, such as he had mentioned, would find a place. He did not know whether the N.P.L. was about to publish anything on cubical integrators, but he felt, personally, that information on this subject would be useful, because there was not much published literature on the subject in the English technical press. The only other point he wished to mention was that he thought it might be interesting to show the meeting one of the flares upon which the experiments mentioned in the papers had been carried out. He did so in order to give an idea of the measurements that had to be made. It consisted of four large Roman candles arranged so as to burn away together, and it would be seen that the intensity of such a large source was rather a difficult thing to measure. The candlepower, which, incidentally, gave an approximately circular polar curve, was probably several tens of thousands, and was of a flickering and variable nature, especially when burned in windy weather. The Committee in charge of this work had been very much interested to see that the same problem had been tackled in America independently, and it was also interesting to note that the American results, as far as they had appeared, agreed on the whole with what had been done here. Further details of the American work was awaited. It appeared to him that there was room for quite a lot of co-ordination in this work, the more especially as flares and bright lights would, in all probability, play an important part in the extended aircraft era which undoubtedly was now developing.

MRS. HERTHA AYRTON said it was a long time since she did any work on the arc, but she was much interested in the cubical photometer. She would like to ask Mr. Walsh whether, when the colour inside changed, he had found any evidence of a straight line move of the particles. When she was working on the arc, she had used an enclosure (not as a photometer), and the straight line move had been a distinct source of trouble to her. When this enclosure had been used for a long time there were lines on the wall similar to the lines of the lamp itself, which showed there must have been some sort of straight line movement. She never investigated it, but she would like to know if anything of the kind had been experienced by other workers.

The PRESIDENT said he was of opinion that the spherical photometer was theoretically the best form, but if the corners of the cube were cut off to make triangles, this would give a sufficiently close approximation to the globe to be worth while doing. It was very easily done.

Mr. C. C. PATERSON said he did not wish people to form the impression that the cube was a very rough piece of

apparatus. In his opinion the sphere was liable to considerable errors by virtue of the presence of foreign objects which must be inside it. The impression at the N.P.L. was that the errors of the sphere were quite of the same order as those likely to be experienced in a cube. The enormous advantage of being able to get inside a large cube and walk about inside, of sliding about, as in a sphere, was obvious, and he did not think if he were going—as he would be—to fit up laboratories for this kind of work he would do otherwise than use cubes. He would expect to get quite as accurate results as any that could be obtained with spheres. So far as he could see he did not believe the total error would exceed two or three per cent.

Mr. L. GASTER said that he was sure that the expression of thanks on behalf of the Ministry would be much appreciated by the Committees of the Society occupied with this work, and they would be only too glad to be of further service in the future. Mr. Blok had referred to the tests on flares made in the United States, and he might mention that some further information relating to the methods followed in these experiments had since been received. The chemical composition of the American samples could not at present be divulged, but it was interesting to observe that the illuminating value attained was apparently higher than that reached in the samples studied by the Committees in this country. Apart from differences in composition, however, the diameter of the sample and the pressure to which the material were subjected were important factors, and it was probable that if the practice in these respects had been identical in both series of tests, the difference in illuminating power would have been much less marked.

With reference to the integrating photometer described by Mr. Paterson, he would like to draw attention to some experiments recently conducted in the United States, wherein a hemisphere was employed instead of a sphere. The method was stated to prove more accurate than the use of a sphere, and it apparently had one advantage, namely, that there was better access of air and freer ventilation. It seemed possible, therefore, that the method would have advantages for testing gas lamps, and he thought it deserved further investigation.

Mr. W. C. CLINTON briefly replied to several points raised in the discussion, illustrating the method of using his photometer. He did not think he could add anything as regards the theory of the curves presented—a question which he believed has been studied by Mr. Walsh, who he hoped would also be able to throw some light on the explanation of the effect of depth of radio-active material.

Mr. J. W. T. WALSH, answering the query by Mr. Blok, remarked that in the process of ageing white paint became yellow, so that when comparing the arc light with the light from a tungsten lamp, any selectivity in the inside coating of the cube would vitiate the results. That was the main difficulty. As regards any evidence of straight line motion, mentioned by Mrs. Ayrton, he was afraid the size of the cube, which was two metres inside, precluded any possibility of evidence of that kind. He had no experience of the use of the hemisphere for the purpose for which it was being used in America. He had only recently heard of these experiments and would certainly look into the matter because it appeared that the possibility of using the hemisphere might be very useful in a branch of experiment which was in contemplation. Mr. Trotter had mentioned the cutting off of the corners of the cube to approximate it more closely to the sphere. That had not been tried. He had no doubt that it would give a better approximation to the sphere and theoretically give better results, but, as Mr. Paterson had said, the difficulties due to the introduction of the necessary screens and auxiliary apparatus inside more than counterbalanced any accuracy which might theoretically result from the use of a sphere rather than a cube.

Mr. A. L. LANDAU (*communicated*): There are some points in the discussion of Mr. Clinton's paper on which something might be said. To my mind the

effect of increasing thickness of material is not difficult to explain. It is clear that the front layers of material will receive additional bombardment from the radium in the material behind, and will, therefore, glow brighter, but have a shorter life, than if a thinner layer of material were used.

Another point is the effect of exposure to visible light in causing a temporary increase in the brightness of radio-active luminous materials. Speaking generally there is no *absolute relation* between luminous response to radium bombardment and to visible or ultra-violet light; that is to say, it would be quite possible to prepare two varieties of zinc sulphide, one of which was very much better when used with radium, but quite inferior to the other in response to visible light, or vice versa. Yet as a matter of fact, *assuming a given type of material* it usually happens that the two qualities go together. It should be noted, however, that the response to visible light is much greater with freshly prepared material than in the case of material which has been aged by radium bombardment; therefore, in the latter stages of the life tests described by Mr. Clinton the possibility of experimental results being impaired by extra brightness through exposure to light is much less.

When we come to consider the effect of artificial illuminants containing considerable infra-red radiation, such as, for example, an electric tungsten lamp or an incandescent mantle, the difference in behaviour of various forms of zinc sulphide mixture is even greater than with daylight. In the case of such exposure there is a double effect: the luminosity is excited by a portion of the visible or ultra-violet rays, and it is simultaneously destroyed by the infra-red element. Now the susceptibility to the effect of the infra-red rays varies very greatly in different specimens. I would not say that this is necessarily associated, in a wide sense, with luminous response to radium (in fact one can prepare materials apparently identical in the latter respect, but most unequal in the former). Yet with the particular variety of zinc sulphide mixture which I have been preparing for use in luminous radio-active paints, it appears that an improvement for the purpose in view is accompanied by a diminution in sensitiveness to the destroying effect of infra-red energy. This may possibly help to explain the different experience which, I understand, was recorded at the meeting by Mr. Clinton and Mr. Paterson respectively. It might quite well happen that in the earlier samples, on which Mr. Clinton and Mr. Dow started their experiments two years ago, the susceptibility to the effects of infra-red energy was so marked that little increase in brilliancy could be detected after exposure to light from the tungsten lamp; but the material now being used might be expected to show a substantially greater effect.

The point arises whether the exposure of the self-luminous compound to infra-red before photometric measurement is quite fair; since infra-red weakens the photo luminescence, may it not also weaken the X-ray luminescence? If the luminescence at any given moment is entirely due to the bombardment at that moment (fluorescence) then the infra-red effect would be negligible: but if part of the total luminosity were due to pre-momentary bombardment (phosphorescence), then the infra-red exposure may possibly dispel this portion and render the photometric test unfair if it quickly follows the infra-red exposure. The point seems worthy of investigation. I do not suppose that the luminosity of self-luminous compound is appreciably affected over a winter-summer range of temperature, and hence the measurements of the authors are not likely to be erroneous through this cause. However, as airships and aeroplanes get to very cold regions of space, and as a very probable use of self-luminous compound will be for steam and other gauges in pretty hot surroundings, an investigation of temperature effects seems desirable.

## INDUSTRIAL RECONSTRUCTION COUNCIL.

### Annual Report for 1918.

In the Annual Report of the Industrial Reconstruction Council for the year 1918 it is pointed out that there are now few trades that have not accepted the principles of the Whitley Report. The organisations already established or in course of preparation for the joint consideration by employers and workers of problems in respective trades and industries fall into four classes: (*a*) Industrial Councils, established under the ægis of the Ministry of Labour in well organised trades; (*b*) Interim Reconstruction Committees formed with the help of the Ministry of Reconstruction in trades where the degree of organisation is not sufficient for the adoption of the constitution of an Industrial Council; (*c*) Trade Boards set up by the Ministry of Labour in trades where the organisation on the workers' side is poor and the wages low, and (*d*) Provisional Committees which have been formed to draft constitutions for Joint Industrial Councils. A list of more than seventy trades is given for which joint bodies, falling in one or other of the foregoing categories, already exist. Frequent additions to the list are being made so that in the future a complete system of industrial self-government may be anticipated.

These results are highly encouraging as illustrating the wide influence of the Industrial Reconstruction Council, exerted through public meetings, conferences, lectures and other methods of propaganda. A list of such coming lectures and conferences, some of which have already been mentioned in this journal, is appended. We strongly recommend all interested in these problems to get in touch with the secretary of the Council, whose address is 2-4, Tudor Street, London, E.C.4.

## PERSONAL.

Mr. Clifford C. Paterson is terminating his appointment at the National Physical Laboratory, Teddington, and is joining the General Electric Co., Ltd., as Director of the Research Laboratories as from January 1st, 1919. Pending the erection of the necessary laboratory buildings, the temporary offices and address of the Research Laboratories of the General Electric Co., Ltd., will be at the Osram Robertson Lamp Works, Hammersmith, London.

Readers will join us in wishing Mr. Paterson success in his new work

## CO-PARTNERSHIP AND THE SOUTH SUBURBAN GAS COMPANY.

The present industrial unrest has drawn public attention to the vital importance of machinery for settling labour disputes and discussing problems of mutual interest to masters and men. Co-partnership, the value of which has been proved by the South Metropolitan Gas Company for many years, has extended considerably in the gas industry during recent years, and offers one of the most hopeful methods of meeting this problem. It is therefore of interest to note the proceedings at a meeting between the directors and employees of the South Suburban Gas Company on December 13th, when Mr. Chas. Hunt, Chairman of the Company, presided. A number of important resolutions were adopted, the following important proposal being passed unanimously:—

"That this meeting of employee co-partners hereby agrees to accept the Co-partnership Committee as a Works Committee for the purpose of adjusting any matter affecting our interests as employees in preference to any other form of Committee, and pledges itself to adopt no other means for the settlement of any matter at issue until the whole machinery of our co-partnership system has been utilised without satisfactory result."

We understand that this Co-partnership Committee is elected half by the workers and half by the Board, and is thus in an excellent position to deal with questions of common interest.

## THE WHITLEY SCHEME AND THE GAS INDUSTRY.

We observe that at a recent meeting of the Edinburgh and Leith Gas Commissioners a report was presented on the formation of a joint committee to deal with working conditions and other matters. An interim committee, consisting of five members appointed by the Commissioners and five by the men, is being appointed pending the setting up of a permanent committee under the Whitley scheme.

## LIGHTS ON VEHICLES.

The following Order, dated December 16th, 1918, and issued under Regulation 11 of the Defence of the Realm Act, is now substituted for the previous regulations bearing on vehicle lights.

PART I.

*Requirements as to Lights to be carried on Vehicles and as to Lighting-up Time.*

(1) Every vehicle on any street, highway, or road to which the public have access, between half-an-hour after sunset and half-an-hour before sunrise, must carry lamps as follows:—

(*a*) At the front, two lamps displaying to the front a white light, except in the case of bicycles, tricycles (other than motor tricycles), or hand-carts, on which only one such lamp need be carried. One lamp must be placed on the extreme off or right-hand side of the vehicle, and the second lamp in the corresponding position on the extreme near or left-hand side of the vehicle; and

(*b*) At the rear, a lamp displaying to the rear a red light. The lamp carried for this purpose on any vehicle except a bicycle or tricycle (other than a motor tricycle) must be placed on the off or right-hand side of the vehicle:

Provided that a hand-cart carrying on the right-hand side one lamp displaying a white light to the front and a red light to the rear shall be deemed to comply with the foregoing requirements of this paragraph; and this paragraph shall not apply in the case of a bicycle which is being wheeled by hand as near as possible to the edge of the roadway.

(2) The lamp or lamps must be properly trimmed, lighted and attached, so that the light from each lamp is visible in the prescribed direction for a reasonable distance without obstruction by any part of the vehicle, its burden, the person in charge, the draught animal, or any animal led at the rear.

PART II.

*Restrictions on the use of electric and acetylene lamps.*

The following restrictions shall apply to electric and acetylene lamps, whether used as headlamps or sidelamps:—

(3) In electric lamps the bulb must not exceed 24 watts or give in use a greater candlepower than the 24-watt (24 nominal candlepower) bulb, as standardised by the Engineering Standards Committee.

(4) In acetylene lamps the burner must not consume more than 21 litres (or ¾ cubic foot) per hour.

(5) The front glasses of:—

(*a*) All electric and acetylene lamps in which the diameter or longer side, according as the glass is circular or rectangular, exceeds 5 inches.

(*b*) All electric lamps in which the bulb exceeds 12 watts or gives in use a greater candlepower than the 12-watt (12 nominal candlepower) bulb, as standardised by the Engineering Standards Committee, and

(*c*) All acetylene lamps in which the burner consumes more than 14 litres (or ½ cubic foot) per hour,

must be obscured with at least one thickness of ordinary white tissue paper, or with ground glass, paint or a disc of some other uncoloured material so that the obscuring effect produced is not less than that of one thickness of ordinary white tissue paper.

The paper, paint, ground glass, or other disc must cover the whole of the front glass and must not be wetted, oiled, varnished or treated in any other way so as to increase its transparency.

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(6) For the purposes of this Order the word "vehicle" shall include any bicycle, tricycle or velocipede, and any hand-cart, and the word "hand-cart" shall include any vehicle drawn or propelled by hand.

(7) This Order shall apply in the whole of England and Wales.

(8) The Lights (Vehicles) Orders of the 9th October, 1916, and the 25th January, 1917, and the portions of the Lights (London) Order of the 21st March, 1918, in force at the date hereof are hereby revoked.

(9) This Order may be cited as the Lights (Vehicles) Order of the 16th December, 1918.

CAVE,

One of His Majesty's Principal Secretaries of State.

Whitehall,
16th December, 1918.

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## REVOCATION OF ELECTRICITY (RESTRICTION OF NEW SUPPLY) ORDER, 1918.

In reference to the following Order made by the Minister of Munitions, namely, The Electricity (Restriction of New Supply) Order, 1918, dated the 8th November, 1918, the Minister of Munitions hereby orders as follows:—

(1) As from the date hereof the said Order is hereby revoked.

(2) Such revocation shall not affect the previous operation of the said Order or the validity of any action taken thereunder or the liability to any penalty or punishment in respect of any contravention or failure to comply with the said Order prior to such revocation or any proceeding or remedy in respect of such penalty or punishment.

(3) This Order may be cited as The Electricity (Restriction of New Supply) (Revocation) Order, 1919.

Ministry of Munitions of War,
Whitehall Place, S.W. 1.
10th January, 1919.

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## CONFERENCE OF BRITISH AND AMERICAN TRADE JOURNALISTS.

A large and representative gathering, called by the Circle of Scientific, Technical and Trade Journalists assembled at the Stationers' Hall on December 19th to meet the party of American Trade Journalists who were on a visit to London as guests of the Government. The party were the guests of the Master and Wardens of the Worshipful Company of Stationers, by whom they were officially welcomed to tea and a reception.

An informal conference was subsequently held in the Court Room, Mr. Gaster (Chairman of the Circle) presiding. Many points of mutual interest were discussed, short addresses being delivered on behalf of the American visitors by Mr. H. C. Parmelee (Editor of *Chemical and Metallurgical Engineering*), Mr. S. O. Dunn (Editor of *The Railway Age*), Mr. H. C. Estep (Editorial Director of the Penton Publishing Co.), Mr. Horace M. Swetland (President of the United Publishers' Corporation), and Mr. Arthur J. Baldwin (McGraw-Hill Publishing Co.).

Some striking instances of the co-operation of the technical press with the United States Government in matters affecting the prosecution of the war were given, and the importance of the technical editor preserving independence of judgment was emphasised, alike by those who were editors and those who were responsible for the management of important technical publications.

Professor R. A. Gregory (*Nature*), Mr L. Pendred (*The Engineer*) and Mr. A. C. Meyjes (*The Ironmonger*), spoke on behalf of the British Press, and entirely corroborated the views expressed by the American Visitors, to whom a vote of thanks for attending the meeting at such short notice was moved by Mr. Pendred and carried with acclamation.

The following Resolution was moved by Mr. H. C. Parmelee, seconded by Mr A. C. Meyjes and carried unanimously:—

"That this meeting of American and British Editors representing the Trade and Technical Press of both nations, records its satisfaction at the alliance between the great branches of the English-speaking race, expresses its earnest desire that the union formed for war purposes should be permanently continued in the cause of peace, and to this end urges a closer co-operation and periodical interchange of views between the Trade and Technical Press of both countries on subjects of scientific, educational and industrial interest."

# TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

## A NEW STREET LIGHTING UNIT.

Great interest attaches to the question of new street lighting equipment now that the end of the war has come. Much of the street lighting equipment in existence before the war is obsolete, and it is anticipated that the half-watt type will play an important part in future public lighting.

FIG. 1.—B.T.H. "Efracta" Lantern (closed).

The British Thomson-Houston Company are making a timely announcement of their new type of street lighting lanterns—the "Efracta" and "Diffracta" lanterns—both types of street lighting equipment scientifically designed for use with half-watt type lamps.

Fig. 1 shows the "Efracta" lantern in its open position. This lantern is of substantial cast iron construction, which is weather and storm proof, and is adjustable so that varying sizes of lamps can be fitted and adjusted in focus in the refractor. The lantern is equipped with the latest type of Holophane prismatic bowl (or band) refractor which provides the most effective combination for securing the wide angle light distribution required in street lighting service. Fig. 2 shows the characteristic light distribution given by this lantern with Holophane bowl refractor.

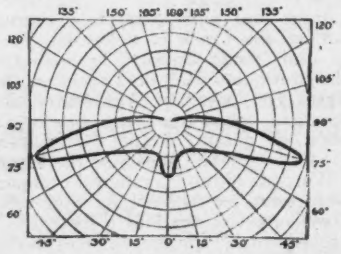


FIG. 2.—Characteristic Light Distribution of Lanterns with Holophane Bowl Refractors.

We are informed that the Illuminating Engineering Department of the company is prepared to assist public authorities in the preparation of up-to-date plans, data, etc., for street lighting. Fuller particulars of the units referred to above will be found in lists 10401—10a/B issued by the company from 77, Upper Thames Street, London, E.C